IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ENGINEERING is the science of controlling the forces and of utilizing the materials of nature for the benefit of man, and the art of organizing and of directing human activities in connection therewith.

As service to others is the expression of the highest motive to which men respond and as duty to contribute to the public welfare demands the best efforts men can put forth, *now therefore*, the engineering and allied technical societies of the United States of America, through the formation of The Federated American Engineering Societies, realize a long cherished ideal,—a comprehensive organization dedicated to the service of the community, state and nation.

Preamble to the Constitution of the Federated American Engineering Societies.

SEPTEMBER · 1920

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Contributors and Contributions

The Need of Research in the Industrial Field

The leading article of the month comes from Dean P. F. Walker, of the School of Engineering, University of Kansas. His subject is one of great importance at the present time, as it is no exaggeration to say that upon the economic status of our industries depends the future welfare of the entire country. Dean Walker has given considerable study to the problem of which he writes. He is chairman of the Research Committee of the Mid-Continent Section of The American Society of Mechanical Engineers, and is also connected with Kansas state organizations actively engaged in this highly important work. His paper thus reflects the conception of these matters as held by those intimately connected with their development, and it deserves careful and thoughtful consideration.

DEAN P. F. WALKER

Alloy Steels, Their Heat Treatment and Uses

The current number contains two papers dealing with the important and interesting subject of the heat treatment of alloy steels. One comes from H. J. French, metallurgical engineer at the Bureau of Standards, the other from A. H. Miller of the research department of the Midvale Steel and Ordnance Company. Mr. French's paper treats of the application of alloy steels, particularly those of the nickel-chromium variety. Mr. Miller's paper deals with the heat treatment of the steels themselves. Both papers will repay careful reading.

The St. Lawrence River Project

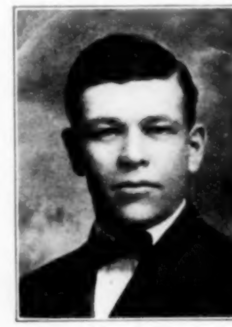
A method of reducing the transportation congestion on the Atlantic Coast is advanced by Mr. Horace C. Gardner in this issue. The long-standing problem of relieving the railroad load during the season of shipping crops to the sea-board may be solved by developing the St. Lawrence River. That this solution must have consideration is believed thoroughly by a considerable number of business men in the Middle West. This paper will appeal to engineers who, as a body, are interested in the great question of the day, that of transportation.

Alloyed Aluminum as an Engineering Material

G. M. Rollason, of the Aluminum Casting Company, writes in this number of one of the most interesting materials known to engineers. Aluminium is a metal which is well adapted to a great variety of engineering uses. Upon its discovery, however, it was proposed for every imaginable purpose, and because it failed to do all that was expected of it a distrust of the metal was created, which even now has not been lived down. Mr. Rollason traces the history of the uses of the metal and its alloys and makes some interesting prophecies as to their future application. He also discusses the methods now employed in its casting and working.

The Training of Engineering Students in Industrial Management

The University of Illinois has one of the largest and best-equipped series of shops for the instruction of its students in mechanical engineering of any technical school in the world. Standard commercial equipment is used, and a regular line of machines is produced on a manufacturing basis. The shops are under the direction of Bruce W. Benedict, who believes that a chief function of the engineer is to manage human enterprises. In this spirit he has developed in connection with the shop laboratories a unique and effective course in industrial management which he describes in this number. In view of the widespread interest in management problems and the training of men to undertake them successfully, this article is recommended for its helpful suggestions.



BRUCE W. BENEDICT

Other Articles of the Month

Dr. Paul G. Agnew, Secretary of the American Engineering Standards Committee, recently returned from a trip to England and the Continent. The current issue contains an abstract of his report describing the status of standardization in foreign countries. A review of accomplishment in standardization work in this country is also given.

The Federated American Engineering Societies is the greatest organization of its kind in the history of the world. Its constitution and by-laws will be found in full on pages 541-543.

The main portion of the Survey of Engineering Progress in this issue is devoted to the problem of Hydraulic Power machinery, its operation and development. This Survey affords an opportunity for keeping in touch with the live issues in engineering.

A.S.M.E. AFFAIRS

In future issues of MECHANICAL ENGINEERING this space will contain brief notices of the current activities of The American Society of Mechanical Engineers. Complete details of all meetings, Committee activities, Council decisions, etc., will be found in Section 2.

THE ANNUAL MEETING
December 7-10, 1920
For Details See Section 2, Page 121

MECHANICAL ENGINEERING

Volume 42 September 1920 Number 9

The Need of Research in the Industrial Field

The Study of the Economics of Location—The Scope of the Work and the Engineer's Part Therein—Industrial Research in the Middle West—The Power Problem in the West

By P. F. WALKER,[1] LAWRENCE, KAN.

The following paper is a discussion of the problems which await the research engineer in the field of industry. The author first outlines the various studies which he considers of fundamental importance. He lays particular emphasis upon the study of the economics of the location of an industry, pointing out in this connection the unfortunate conditions which now exist in Kansas and the neighboring states solely because this problem is as yet unsolved. The solution of the problem, the author states, is distinctly an engineering one, and he accordingly next presents a discussion of the engineer's part in the field of industrial research. He also outlines the scope of the work which in his opinion should be undertaken. The concluding portion of the paper is an abstract of a report prepared by the Research Committee of the Mid-Continent Section of The American Society of Mechanical Engineers, of which the author is chairman. It deals with the status of industrial research in the Middle West and covers all phases of industry. It is divided into three groups: (1) the food group, (2) the fuel group, and (3) the miscellaneous group, the latter comprising such industries as mining, cement manufacture, metal manufacture, etc. The paper is a comprehensive summary of the status of industrial research in the Middle West and a concise statement of the great need for such research throughout the entire United States.

INDUSTRIAL research is a term now coming into frequent use. There appear to be, however, about as many variations in the meaning assigned as there are persons using it, so it may not be out of place to briefly discuss its several phases before giving attention to the particular kind of work and study to be discussed in detail. This is not for the purpose of imposing the writer's personal definition on any one, but merely for the sake of clearness.

Strictly speaking, all engineering research is industrial. So also is all research in either pure or applied science laboratories, if the results are of a nature such that they can be given direct application in industrial operations or designing. One of the most apparent tendencies is to make a distinction between the laboratory of a public institution and the laboratory of a manufacturing or other business firm, calling the work done in the latter industrial research. As a matter of fact the same kind of work may be going on in both. The private firm, it is true, is looking for results applicable to its own business, but the results of the other may also be applicable there. It is a distinction based on motive, and form of organization, rather than on kind of research.

Another distinction is sometimes made by placing the study and development work carried out with commercial equipment already in operation in the business, in a different category than similar work being done for the purpose of experimentation with equipment set up to simulate operating conditions. Both, presumably, are technical studies, and the only possible difference lies in the facilities which may be provided in the latter case for securing observations. Such a distinction would have the effect of branding industrial research as inferior in scientific character and perhaps superior in commercial value. This is obviously an improper sort of classification.

[1] Dean, School of Engineering, University of Kansas. Mem. Am.Soc. M.E.

A distinction based on the character of the work is made by including in the term "industrial" the study and analysis of organization and management problems, as distinguished from technical work based on physical science. This view is well represented in the interesting article by Mr. Hirshfeld in the February 1920 number of MECHANICAL ENGINEERING. Industry is now in that period of development where the most marked increases in the rate of production come from development of the works personnel, rather than from refinements in mechanical equipment. Many of these developments are far past the experimental stage in some branches of industry, but work still remains to be done to show results in many others.

The Study of the Economics of Location

But there is still another line of study that can be called industrial research, different in kind from work based on physical science. It has to do with the economics of location of industrial enterprises and with the possible development of natural resources in any given locality. In order to make a clear statement of the methods that may be followed in such work certain general principles will first be given a brief discussion. In passing, it may be observed that the war called attention to the importance of developing certain essential industries in this country, and this fact while somewhat aside from the main line of thought, is of prime significance.

The distribution of goods is the greatest industry in the world. In the United States it has become especially large in comparison to other activities, because of the great extent of country and the high per capita wealth which stimulates buying. The absence of a peasant class means that in every nook and corner of the land people are in the market for the highest classes of every line of commodities. This means that shipments of standard goods follow population groupings in approximately uniform quantity.

What this means is indicated by the following illustrations. In a simple everyday commodity like starch the state of Kansas calls for the shipment of 2000 tons annually, the haul being mainly from Illinois and eastern Iowa, an average distance of perhaps 500 miles. This means one million ton-miles of traffic imposed on the railroads, although Kansas ships out many thousands of tons of corn.

A single small city in Kansas, Garden City, on the main line of the Santa Fe railroad, ships thousands of tons of alfalfa meal and dried sugar pulp for dairy feed to the southern states. The town does not have even a small dairy-products plant, hence it must in turn ship in its butter, notwithstanding the fact that it is in the midst of a cattle country. In varying degree this statement applies equally well to scores of towns in several states. The dairy-feed traffic probably amounts to several hundred millions of ton-miles annually, near half of which could be eliminated by a scientific distribution of manufacturing enterprises.

A condition more vitally wrong exists in the handling of lead and zinc ore. Forty per cent or more of the output of the United States comes from a small area near the corner junction of Oklahoma, Missouri, and Kansas, a few miles east of the oil and gas belt. The concentrated ore is first shipped to smelters in the gas field, a proper procedure because it saves transportation of fuel. But from here the greater part of the spelter in semi-

crude form is shipped to New Jersey, and finally the finished metal, in sheet or other stock forms, is again shipped, some to the states of its origin, and much of it to states much nearer that origin than to the rolling mills of New Jersey.

Many other instances of unnecessary traffic might be cited. An unavoidable freight producer is the group of standard food products—meat, fruit, and cereals. The origin of this traffic is in the grain belt west of the Mississippi River, on the stock ranges of the West and Southwest, and in the fruit districts of the Pacific and Gulf states. Granted that, in the main, the movement is always toward the markets, a greater saving will nevertheless result when the center of population moves further westward from its present location in Indiana and this will be accomplished as the trans-Mississippi states experience the industrial development which the full utilization of their resources makes reasonable.

As a matter of fact, the agricultural states are facing a disturbing situation which has a reflex effect on the country as a whole, threatening the food supply of the nation. These states are near a standstill in population, if not actually losing ground. Out of the 105 counties of Kansas, sixteen prevented the state from declining in population during the decade ending in 1915. These sixteen are the ones having the important manufacturing industries and hence the largest cities. The agricultural counties lost in the aggregate. The same thing holds in Iowa, and doubtless in other states for the same period. This means an undeveloping home market. It means further the absence of those large masses of labor usually found in industrial centers and so necessary during wheat harvest. The seriousness of this lack of labor at the peak of the agricultural load is not realized by people far removed from the grain states. In 1919 the farmers in western Kansas counties were paying eight and even ten dollars per day, and usually for incompetent labor, and even at that were short-handed. This condition so increased the cost of production that in many cases in spite of the high price of wheat net incomes were almost wiped out. The result has been that the farmers are reducing the acreage to an amount that they can handle with their own labor plus the neighborhood exchanges. This is menacing the food supply. Many a farmer is also without funds to pay his 1919 bills, because the railroads have not been able to move the wheat. The writer has talked with farmers in several of the largest wheat counties of Kansas, and knows that these statements are in accord with the facts.

Some one has said transportation is the neck of the bottle that limits the capacity of the country to produce. But while waiting for the railroads to recoup themselves, why should not industrialists bestir themselves in an effort to check the ever-growing load of freight by a more systematic plan of production? When viewed from the standpoint of a national industrial system industry has grown in a haphazard fashion as to location. Business instinct has been logical and true within the recognized sphere of determining factors, and master minds have built up our successful enterprises. But the controlling factor has been cost of production, based on the assumption that transportation facilities would be adequate to bring the materials and carry the goods to market, irrespective of distance. Sometime a limiting condition will be set on this assumption, and it may be that the time is nearer than has been supposed. It is not too soon to begin to consider a national industrial policy, based on economy of combined production and distribution, in which the associated problems of food and fuel supplies will be given their due consideration.

The Engineer's Part in Industrial Research

The basic principles on which such a coördinate system must be established are scientific in character. It is an engineering problem that is involved, in which the economies of transportation and production are in the foreground. It is the business of the engineering profession to recognize the need and to proceed with the study and analysis of the vital facts. Too often engineers hesitate to enter upon projects wherein financial and economic situations are the first to be met, even when the forces most directly influencing those situations are technical and such that the man with engineering experience can most readily pass judgment upon them. Production and transportation, taken separately, are matters subject to scientific analysis, with which engineers have long dealt. In combination they are no less susceptible to such study and the need for a scientific system is becoming more and more evident.

The investigations in which the writer is now engaged form but a slight part of the complete survey and study indicated by the preceding statements. An attempt is being made to analyze the industrial possibilities of the state of Kansas. It is being done with the coöperative support of the governor's office, and of the state department of industry and labor. Whenever it should become necessary the authority of those administrative agencies may be invoked to open the doors to information respecting individual enterprises, but diplomacy has been uniformly successful in securing all that is needed. Another coöperating agency is the Kansas Engineering Society, of whose standing committee on manufacturing industries the writer is chairman. Also the writer's position as head of the research committee of the Mid-Continent Section of The American Society of Mechanical Engineers is of contributory value, particularly as regards the petroleum industry. Likewise the fact of his being head of the engineering branch of the state university fixes his status as practically that of a state official in such matters. These points of a somewhat personal nature are mentioned merely to show the means at command for making a consistent statistical study of existing conditions.

The Scope of the Work

The work under way naturally divides itself into three branches:

1 A survey of operating conditions in existing enterprises
2 A study of industrial needs of the state
3 A study of the vital economic factors in such kinds of manufacturing as Kansas resources and conditions make it feasible to consider.

Along with these branches of individual effort a certain form of educational campaign has been conducted. The means for this has been an association with the chambers of commerce of the cities, by speaking before gatherings, conference with committees, and providing secretaries with statements of facts as to individual industries. This is akin to promotion work, and as a matter of fact some real promoting is being fostered at the present time. This is special, however, and essentially a private enterprise.

In the survey of existing enterprises the usual routine of the census enumerator is amplified. Volume of business, capital, quantity or value of raw material, employees and payroll, and power, are interesting and valuable items, but in this study the following facts are more to the point:

1 Markets and marketing methods. The section of country served, the nature of the demand for the product, relations with other industries, and trend of development are points of information sought
2 Sources of raw material. Actual original source and the freight rates or other cost of delivery to the plant
3 Transportation facilities, for both raw and finished stock
4 Details of power and fuel supply, cost, etc.
5 Labor conditions. Questions of supply and quality of labor, aptitude of residents of the community for specific kinds of work: also the local situation as to balance in employment opportunities for men and women
6 Reasons why the enterprise was located as it was. Sometimes this reveals only some personal preference, but often there is a well-considered reason
7 Business and social conditions of the town and community.

The second branch of the work—the industrial needs of the state—presents several distinct features. For different regions the problems are different. Many think of the state of Kansas as one great wheat field with a few cattle ranges interspersed. As a matter of fact there is a wide diversity of natural products. In the southeastern counties are the mining interests in coal, lead, and zinc. Just west of that and extending half way across the

state is the petroleum district. North of the western end of the oil belt in central Kansas are large deposits of a good grade of salt. In several counties, some northeast and some south of the salt deposits, there are large quantities of workable gypsum. In many sections the clays and shales are furnishing materials for cement, brick, tile, and other ceramic products. Corn, as well as wheat, is grown in all excepting the far-western counties, but almost nothing is done now in the manufacture of corn products. Sorghum cane and its products hold important possibilities, but lightly touched upon as yet. The dairy-products business holds most promising possibilities and is destined to become an important factor soon. Large portions of the seemingly dry western counties have abundant ground water within pumping distance of the surface. Irrigation has been practiced successfully for the growing of sugar beets and alfalfa, and much is to be expected from further developments. Canning and preserving of vegetables and fruit is an industry that has not yet begun to touch its possibilities. These and several other industries are of great promise, many of them being needed to change agricultural methods from extensive wheat growing to an intensive system with diversified crops, the better to realize the food-producing capacity of the soil. Industries producing lines of goods in metal, leather, paper, and cheaper fabrics, already represented in several cities, are capable of extensive development. Any line of manufacturing which produces goods expensive to ship in finished form, from raw material that can be shipped in bulk on a low freight tariff, can be operated successfully in this region. These comments illustrate the line of investigation without covering at all adequately the possibilities of this or any other region.

The third phase is the logical one of analyzing carefully many different lines of manufacturing to determine which ones are best adapted to the conditions in any given locality. Those requiring large amounts of power or process fuel, like the smelters and cement mills, must cling to the coal and oil districts. For others the power demand is small and they may follow markets or raw material. Those for which the value added by the manufacturing process is large can go anywhere, other factors being equal and provided the labor supply is in sight. It is here that we have the final application of all that has preceded, namely, the fitting of the enterprise to the locality. No task is more interesting than the one of providing a locality with an industry or an industry with a locality.

It is submitted that this is a form of service to the state or other district that warrants the attention of engineers. It is a step toward the great enterprise of establishing a comprehensive industrial system that shall take into intelligent consideration all of the factors of production, markets, economy in transportation, economic distribution of population, and maximum utilization of the food-producing power of the country. We have been prodigal in the exploitation of natural resources, but the end of this is coming. To become a true industrial nation means the extension of scientific methods to the broader problems of industry.

Industrial Research in the Middle West

As a definite example of this form of service to the state the writer desires to present, as the concluding portion of his paper, an abstract of a report prepared by the Research Committee of the Mid-Continent Section of The American Society of Mechanical Engineers. This report was based upon that society's action in calling for information regarding industrial scientific investigations in the Mid-Continent Section territory; (*a*) On such topics as may be so well worked out as to warrant a final statement of results; (*b*) On problems now in process of solution or development. A further point was the formulating of information as to facilities available for carrying on research work in the several industries and educational institutions in the same territory. Still another was to take such steps as might be possible toward the securing of funds to be applied in the support of investigations having as their object the improvement and development of the varied industrial interests of that section of the country.

In compliance with this request the committee has applied itself to the carrying out of the program, particularly as to the gathering of data pertaining to investigational and development work now in progress. Circumstances have required, however, that the writer who is chairman of this committee should formulate the report without conferring with other members on matters other than the general intent and scope of the work to be undertaken. Opinions expressed herein are therefore largely his personal ones, for which he assumes responsibility. In general it is to be understood that the ideal that guides in this work is to promote the best interests of the people of this large Mid-Continent area, which in turn touch the interests of the entire country in a most vital manner. Engineering is a profession of service. It is given to engineers to bring the energies existing in nature to the use and convenience of man, and the first concern of those who study the industrial needs of an inhabited region is the economic betterment of the population along lines that are permanent and in accord with a sound national policy. Individual industries are to receive the direct study, of course, and the benefits of such development as might be stimulated thereby, but the motivating impulse lies in the general aim just expressed.

The Scope of the Industries

The industries of the territory which have received consideration may be grouped as follows:

A—The food-products group, including
  1 The beet-sugar industry
  2 The dairy-products industry
  3 The canning and preserving industry

  Note: The two largest industries of this group, meat packing and flour milling, are not included because they have reached such a stage of development as to make generalized study unnecessary, excepting as to choice of motive-power equipment in flour mills.

B—The fuel group, including
  1 The petroleum and petroleum-products industry
  2 Coal mining.

C—Miscellaneous, including
  1 The zinc and lead mining and smelting industries
  2 Cement manufacturing
  3 Metal manufacturing
  4 Other manufacturing, considered as to conditions influencing possible development.

The Food-Products Group

Research work among the industries producing foodstuffs is of that kind having to do with economic conditions influencing their establishment. This is a territory that produces much and is capable of producing much more. The soil is made to yield only a fraction of what intensive methods would make possible, this being strikingly true of the western portions of Kansas and Oklahoma. To bring about the change there is demanded a development in the field of engineering.

The great need of the section of country referred to is for power. Irrigation is necessary to make sure the crops, and this would be provided from the unfailing sheet of ground water if cheap power were obtainable for pumping. In some sections the start has been made, but the mounting cost of fuel oil is making continuance difficult and uncertain.

The Fuel Group

On the coal-mining branch comment has already been made with respect to possible development of a coking and by-products industry. In mining itself the problems are largely with respect to labor and social conditions. Investigations are contemplated by the mining staff of the University of Kansas on such questions as the percentage of extraction being secured under the mining systems now in vogue, and on economic advantages arising from electric underground haulage. It is understood that similar studies are under way in Oklahoma. Engineering problems are much more serious in the Arkansas coal fields than in either

Kansas or Oklahoma, but no information has been secured as to specialized work in that field.

The petroleum industry occupies the center of the stage in this territory, and necessarily comes in for a major share of attention. It has often been said that there is very little scientific engineering work carried on in the oil field. At one time in the history of the industry, undoubtedly this was true. Conditions now are very different, however, and while there are still found those regions where in the flush of new development the methods employed are wasteful in the extreme and based largely upon rules of thumb and traditions handed down through the old rough-and-ready type of oil men, there is at the same time being applied in the representative districts where well-organized companies are in control, a degree of engineering talent and skill not to be surpassed in any industry of the country. Margins are not what they once were, and, in spite of the apparently high rates of return, the safety of the excessively great investments in what may in many instances prove to be short-lived enterprises demand a close and accurate study of those conditions which lead to economy. To the same end there has been necessary a large amount of study and research in the development of processes and of specialized equipment that have made possible the effective handling of an elusive substance upon a basis profitable for the investor and adequate for the market. The uninitiated would be surprised on discovering the amount of attention being given to these scientific problems which have a direct bearing upon the commercial issues of business.

It is necessary to appreciate the demand which is being placed at this time upon the producers of high-grade liquid fuels. This demand is increasing rapidly and the public press is employed frequently by those who would express their convictions that a crisis is being approached when supply will no longer be sufficient to meet demand. It is said by many that the peak of oil production has been reached. It is not in the province of this committee in its report to express opinions on this point, but it is not out of place to remark that the apparent limitations to production in the Texas fields need not occasion as much alarm as it seemingly has in some quarters. There is evident a renewed interest in pushing forward new developments in older fields of Oklahoma and Kansas, particularly in the way of reaching sands considerably deeper than those which have been producing for many years. Results obtained are highly gratifying and there is ample evidence of the existence of a great storehouse of petroleum that as yet has been drawn upon but lightly. This is of particular significance in the present connection because it gives assurance of the continuance of the industry over a period of years during which there may be put into effect the many advanced methods now being perfected in both the producing and treating of oil. It is this which gives special significance to the scientific work that is being carried on.

Our topic divides into two parts, representing the major fields of activity. These are, first, the production of oil, and second, the handling and refining of the oil when once it has been brought to the surface.

Production Problems. It is of first importance that there should be drawn from the producing sand the largest possible percentage of the oil contained therein. How it may be increased is one of the greatest objects of study, and many suggestions have been made covering a wide range as to feasibility of methods. Perhaps the most extreme suggestion is that some day we shall be mining the oil sand, bringing it to the surface for the application of extractive processes more frequently associated with the handling of oil shale. To the practical oil man, however, the first step is the perfecting of producing methods. With lessened cost of production, wells can be operated down to a correspondingly lower output and the sand more completely drained. With lessened cost of drilling, wells may be more numerous and contribute to the same end. With this in view reasearch activities have been directed toward the following:

1 The development of more efficient types of deep-well pumps
2 The development of more efficient types of power-generating equipment as applied at the well
3 The application of new forms of power equipment, notably the introduction of electric power for deep-well and surface pumping and also drilling
4 The recovery of oil from the troublesome water-oil emulsion so commonly met with in most producing fields
5 The perfection of methods for extracting the gasoline otherwise carried to waste in vapor with natural gas, commonly designated as plants for manufacture of casing-head gasoline
6 The problem of water supply, frequently a serious one where quantity and quality of the water are vital factors
7 The development of accurate metering devices for both oil and gas.

A great amount of time, talent, and capital has been expended upon each of these problems, upon any one of which a complete paper might well be written. To the writer the most interesting and seemingly the most striking of these are the application of electric motors in the field, the perfection of dehydrating plants for the recovery of oil from emulsion, and the casing-head gasoline plants.

The accomplishment of the first of these three is dependent upon a supply of electrical power. This condition is met in most admirable manner in the El Dorado field in Butler County, Kansas, where a high-voltage power line leads directly from the plant of the Kansas Gas and Electric Company of Wichita to a substation maintained by the Empire Gas and Fuel Company. From this substation current is distributed to the entire field. A great amount of specialized design was necessary in order to produce machinery adapted to the service, but this has been accomplished in a most creditable manner. It should be observed in passing that continuity in operation is a most important factor in preserving the productivity of an oil well.

No one problem has called for more careful study than has the design of dehydrating plants for the recovery of oil from emulsion. Probably the most effective system has not yet been evolved. The one in most common use involves the centrifuge principle, wherein the last step in extraction is brought about through centrifugal force. Efficiency of this system is such that less than one per cent of water remains. One process which has been demonstrated to be successful involves the principle of passing the water-and-oil mixture through a strong magnetic field, breaking the oil film and permitting the water to separate at once by gravity. Developments in this line are rapid, so that one sees much discarded equipment which has become obsolete in the presence of improvements.

In the field of production of casing-head gasoline there is active discussion as to the relative merits of the two systems, designated as the compression and the absorption methods. Experience seems to indicate that each one has its field of application. Apparently the gas less rich in condensable vapor is handled more effectively by the absorption method.

To further illustrate the investigational work which the successful operation of an oil property makes necessary, the following researches accomplished by one company are mentioned. These tasks have been accomplished through detailing to the work regular members of the operating staff of a single department.

1 The conducting of an extensive series of tests for volumetric efficiency of compressors drawing gas from wells under widely varying pressures. This was especially well done when considered as an isolated piece of work, and made possible the proportioning of equipment to demand on a scientific basis
2 The carrying out of extended tests on total gasoline content of gases before and after the application of the casing-head gasoline process
3 The determination of shrinkage of volume of gas while being thus treated by the compression method
4 The determination of evaporation losses from blends of casing-head gasoline with heavier oils when handled at different temperatures.

Handling and Refining Problems. In the transportation of oil by pipe line much analytical work has been done which cannot be

reported upon in detail. Records of this work are in the files of the larger companies, and all that can be said is that engineering talent of a high order is being employed in maintaining service.

Problems that are obviously calling for solution in the development of equipment are those relating to the determination of constants for the flow of heavy oils in pipes, and the development of more efficient pumping machinery. Here again the question of power supply enters as a factor. With this mere mention the question of pipe-line transmission will be dismissed.

The problems of the refinery are many and complicated. Many of them come within the range of the chemist rather than of the mechanical engineer. Development work to perfect the process of cracking of oils to increase the yield of gasoline still continues, many companies being engaged in this work.

With the larger refining companies the following are problems continually discussed and for which the positive final solutions have not been found:

1 Determination of the exact amounts of heat required to vaporize oils of different densities and characteristics
2 The rate of conduction of heat through metal surfaces where oil is one of the media involved in the transfer
3 The proper design of furnaces for stills when handling (*a*) crude oil; (*b*) residues under pressure
4 The coefficient of expansion of oils
5 Fuel-economy problems, including the design of the most efficient oil burner
6 Devising of a method for the mechanical separation of wax from lubricating-oil stock
7 Successful methods for the treating of sulphur crudes
8 The development of synthetic processes for by-products, such as ammonia, dyes, perfumery, etc.

Progress in refining methods in the petroleum industry is of peculiar importance. Developments which have been made in recent years have greatly increased the production of the lighter and more valuable fuels, without which the market today would be in a much more critical condition. The chemist and the engineer are working together to improve existing methods and to devise new ones, and the end is not yet. All of the eight unsolved problems mentioned are subjects of study from which a mass of valuable data will be forthcoming in the near future.

The Miscellaneous Group

The lead- and zinc-mining industry is one of the most important activities in the Mid-Continent territory. What is needed most is a stabilization of the demand for zinc plate. This metal is adaptable to many uses outside of the galvanizing and alloy business, and some pioneer work along this line would be productive of results. Some of the same conditions hold for the cement-manufacturing industry. This is a line of business, however, for which an active organization directs the necessary advertising and maintenance of market conditions.

Only one line of research is mentioned, namely, a close study and analysis of power distribution and costs, which has been in progress for some time at the plant of the Lehigh Portland Cement Company at Iola, Kan. That work was interrupted by the war, but will be renewed during the next year.

Metal manufacturing in the territory has been added to by the installation of several new plants which are engaged mainly in the oil-well supply business. One thing greatly needed is a source of supply of a good grade of metallurgical coke. Important investigations on possibilities of coking the mid-western coals are under way in Illinois and Kansas, and it is hoped that some help will be afforded the foundrymen in the not far distant future.

The Power Problem in the West

In preceding sections reference has been made to the need of cheap power for several important industries. This is a matter that is holding back industrial development in a large area. Coal in the region west of a north-and-south line not far from Tulsa is scarce and high in price. Under ordinary conditions oil is too valuable a fuel for use under steam boilers, and its availability for internal-combustion engines is becoming limited while the high price is having a marked effect on cost of generation of power in small units. Present assured markets make the promoting of an extended system of interlocking generating plants markedly hazardous.

Conditions indicate a possible revival of the producer-gas enterprises that were checked in development by the rapid extension of the petroleum fields about fifteen years ago. The lignites of the northwest hold the balance as regards original sources in this matter. The successful outcome of such a proposition rests with the engineering profession, and a reward is in store for those who provide the solution for this on a large scale. Before it can be accomplished, however, it will be necessary to construct a new line of north-and-south railroad connecting the northwest with this great semi-arid region in the western portions of Kansas, Oklahoma, and Texas—a bit of railroad construction that is well worth considering. The region in question has untold possibilities for the maintenance of the food supply of the nation.

Research Agencies in the Section Territory

The exclusively research institution in the territory is the Oil and Gas Experimental Station of the United States Bureau of Mines located in Bartlesville. The station has been active on several phases of the oil industry, its principal lines of study at the present time being:

(*a*) Dephlegmating towers for refinery stills
(*b*) An investigation of the underground conditions of the Hewitt Field
(*c*) Increased recovery from oil properties
(*d*) Evaporation losses from storage tanks
(*e*) The recovery of gasoline from uncondensed still vapors in refineries.

It has also taken up the question of water supply and the effect of water impurities on oil products.

There are three state universities and two state colleges of agriculture and mechanic arts within the limits of the territory. Research facilities exist at all of these institutions, and in at least three of them active steps are being taken to engage in investigations of direct interest to the petroleum industry. Mention has been made of work in progress at the University of Kansas. In addition a productive study has been made during the year just ending of the treatment of oil shale. Plans are now definitely made for taking up in the fall two of the problems mentioned in the refining section: namely, the conduction of heat through metal plate with oil as one of the media of exchange, and the latent heats of evaporation of oils of varying gravity. At the Oklahoma institutions preparations are being made for an extended study of chemical problems.

But the significant element in research in this territory is the part taken by the organized staffs of the larger oil companies. All have engineers and chemists whose time is given in considerable part to new problems, and if all that is being accomplished in this way could be brought to light the extent of the work would be a matter of much surprise. In this organized work the Empire Gas and Fuel Company holds a conspicuous place with its full-fledged department of engineering research. An independent agency like this committee can gain access to the results of such activities, and by adopting a conservative policy as to publication such as will retain it in good standing with the companies which cannot be expected to throw everything open to the public which it has learned through the expenditure of much effort and money, it can accomplish much for the good of the profession of engineering and of the industry.

The time is ripe for bringing to bear upon this important industry the best and united efforts of all technical and scientific men. Quoting from a recent publication of the Bureau of Mines: "The time has arrived when, with crude oil higher than it has been for 50 years, inefficiency in the production and manufacture of petroleum should not be countenanced. Petroleum and its products should be reserved for those uses for which it is peculiarly adapted and for which there are no substitutes."

The Training of Engineering Students in Industrial Management

By BRUCE W. BENEDICT,[1] URBANA, ILL.

The author of the following paper presents the details of a pioneer experiment in the method of teaching industrial management to engineering students. The field of engineering is broad in its scope and purpose and there is a constant call for men trained to perform a multitude of diversified tasks. The technical schools, however, cannot attempt to train men for special tasks, but the presentation of the fundamentals of engineering must nevertheless be governed by the needs of present engineering practice rather than by traditional academic considerations. With this thought in mind the University of Illinois has organized its school shops upon a commercial basis, the details of the system employed and the manner of conducting the work being described by the author. The plan is an exceedingly simple one and is based upon a recognition of the fact that the engineer is primarily a manager of human enterprises rather than a technician making plans for others to execute. The paper is not intended to present the specifications for a complete course in industrial management designed to develop executives and managers from untrained men within the course of a few weeks, but it does outline an experiment in the development of engineering leadership which it is hoped will be fully realized.

If we accept the proposition that "the ultimate aim of engineering is reduction in cost of the elements of living through the development of improved facilities for changing raw materials into usable products," we have a definite guide for the training of engineers, and the prospective engineer has an equally definite ideal to direct him in preparing for and carrying on his life's work. It is not certain that technical schools generally have been guided by ideals which embrace the broad function of engineering as just defined, nor is it clear that the engineering profession as a whole is, or has been, inspired by adequate conceptions of its task. Engineers to a great extent have narrowed their field of activity to design and construction. Their genius has been directed toward the building of engineering works, but with the completion of the physical structure they have taken themselves off to similar tasks elsewhere, leaving operation to other hands. Operation is a prime function of engineering. It is the final link in the cycle which makes engineering work of value to man, and engineers must, if they see their task in its true perspective, assume the responsibility not only of creating improved production facilities but also of operating them.

The limited conception of the field of engineering held by engineers in general is due in no small part to the influence of the technical school. No one questions the high sense of duty and the devotion of engineering educators, but because of the limitations imposed by inadequate financial resources, the absence of the human factor in laboratory and classroom exercises and the detachment of college environment from affairs of the world, the technical school has been unable to construct a curriculum that reflects the larger ideals of engineering as expressed in the opening paragraph. Lacking a real engineering setting and having no direct need for consideration of those economic and human factors which enter so largely into the practice of engineering, the technical school has to a large degree ignored them in its treatment of engineering subjects. Gradually the curriculum has been developed around the idea that proficiency in the solution of mathematical and scientific problems constitutes the proper initial training for engineering work. Unquestionably the preparation for theoretical and material problems of the engineering profession has taken precedence over the larger task of developing the fundamental qualities of leadership not only from the reasons mentioned above but also from the belief that knowledge of practical affairs is to be acquired in practice after graduation. Allowing for the fact that experienced teachers can and do mold the most rigid curriculum into practical and inspiring forms, we cannot avoid the conclusion that the conventional scheme of technical training, as organized and applied, tends to produce technical advisors rather than engineering leaders.

Industry absorbs the bulk of engineering talent and young men entering this field of endeavor must be prepared for exceedingly complicated tasks, involving, in addition to mathematics and science, a thorough knowledge of economics, of production and of men. Technical courses taught on the basis of pure theory without reference to the latter factors certainly do not meet the need of a large majority of young engineers for conditions confronting them at this time.

Without lowering in any degree the pressure on fundamental theory, instruction must emphasize the importance of the factors of time, cost, production, safety, and of the human element. Even the fundamentals, mathematics and science, must be given new life by teachers who look at these subjects as tools of the engineer, instead of as academic exercises for training the mind.

The Scope of the Engineering Field

The field of engineering is broad in scope and purpose. It calls for an increasing force of trained men to perform a multitude of diversified services. Notwithstanding appeals for men with particular training, the technical school cannot attempt the preparation of engineers for special tasks. It must seek to promote knowledge of engineering fundamentals to the exclusion of technical skill required in specialized branches of engineering and of industry. But the presentation of fundamental matter should be governed, as previously suggested, by the needs of present engineering practice rather than by traditional academic considerations. It goes without saying that all will not agree with this proposal to liberalize present curriculums. The reasons formerly considered as fundamental are in opposition to the views expressed, but it is questionable whether the arguments employed to sustain them are entirely effective under present conditions.

We may consider the engineer as a technician or as an operator; we may carefully define his ideals and his tasks; we may prepare him for a certain type of service, but the composite result will be naught if our subject cannot produce and produce cheaply. Now the engineer is preëminently a producer, a producer of something useful to man, and it is obvious that his training must be organized to fit him for this task. The technical school is responsible for what is roughly the second training period, and if it fails to contribute its full share to the effective preparation of the engineer for the services demanded of him, we may expect the pressure of need eventually will force an adjustment in methods of training. To this, the ultraconservative will not agree, since to him it is a mistake to change the existing order. But educators are beginning to see more clearly that methods of training to be effective must respond to the developments in engineering practice, and also that a change in method necessarily does not effect a correct application of basic principles. In recent years technical education has undergone a number of striking modifications, which indicates a growing effort on the part of the technical school to keep pace with developments in engineering practice. Among these we note: Direct coöperation of technical schools and industry in administering joint courses of instruction; establishment of specialized courses in technical schools for employees of engineering and industrial concerns; organization of post-graduate courses with highly technical aims by industrial concerns with the assistance of the technical school; establishment of new colleges of industrial

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Abstract of a paper presented at the Indianapolis Mid-West Sections Meeting of The American Society of Mechanical Engineers, Oct. 24 and 25, 1919.

organization, commercial engineering, chemical engineering, ceramic engineering, operation and management, etc.; introduction of courses covering a wide variety of technical subjects; and lastly, the promotion of a closer working relationship between practicing engineers and the technical school. These developments have not lowered the status of engineering education; on the contrary, they have greatly enlarged the usefulness of the technical school and brought to it a larger measure of support from those interests directly concerned with engineering affairs.

While progressive educators recognize the fact that technical education is entering upon an era of more effective service, they are not agreed as to definite lines of development. With a problem so complex as this, agreement as to policies and details should not be looked for; in fact, concurrence of views in respect to this matter is an impossibility from every standpoint. The cause of technical education will be advanced most rapidly by the development of distinctive policies and a frank exchange of ideas about them. It is this thought that prompts the effort to describe the plan of training engineers in the principles of industrial management at the University of Illinois. Although it is recognized that a large majority of engineering graduates enter industrial work, a special course of study for training engineers in industrial management has not been established at this institution. This policy may be modified in the future, but the belief still prevails that the best preparation for the practice of engineering, in all branches, is a thorough grounding in the fundamental subjects of mathematics and of science, coupled with a certain amount of specialization in particular engineering subjects. The main engineering courses seem to satisfy, for the time at least, these general requirements. Consequently no attempt has been made to provide a special curriculum for men expecting to enter industrial work. On the other hand, it was felt that engineers should be given definite training in the principles underlying the management of men engaged in productive enterprises, which led to the adoption of a new policy in administering the traditional shop-work courses.

The Commercial Organization of Technical-School Shops

It is not the intent of this paper to discuss the changes in methods and ideals which have been made in the shop courses at the University of Illinois, as these possess little interest in comparison with the more vital topic: What is being done now and with what results? The plan is a practical application of the theory of engineering as expressed in the opening paragraph. It recognizes the engineer primarily as a manager of human enterprises rather than as a technician making plans for others to execute. And again the plan represents the new spirit in engineering education of which mention previously was made, as it was developed on the theory that training for engineering tasks must join with the study of fundamental subjects, actual experience with processes of production. To provide a medium for carrying out the latter part of this program, in the year 1912 the shop laboratories were organized on the lines of a commercial plant for manufacturing gas engines. The plant consists of five departments: pattern, foundry, forge, machine, and assembly. Each department, except the latter, is in charge of a superintendent who is responsible for both operation and instruction. An assistant superintendent, mechanics and toolroom attendants complete the departmental organizations. An assistant manager looks after plant operation. Final authority on all matters is vested in the office of manager, who is responsible to the head of the department of mechanical engineering. The instructional staff serves as a shop committee and acts in an advisory capacity on important matters.

In the plant itself the most effective production methods within the existing limitations are in use or being installed. All shop operations are standardized and covered by detailed instruction cards. Jigs and fixtures and special tools are generally employed. Machinery is effectively grouped and maintained in operating condition, and equipped with safety guards and devices. Modern tool stockrooms with stocks of standard tools and supplies are maintained in each department. Approved methods of routing, dispatching, inspection, and transportation of parts are effective throughout the plant. Control and storage of materials is effectively carried on by accepted methods. In respect to methods and facilities for the production of work, the shop laboratories may be considered as representative of the better type of small commercial plants manufacturing similar products. It has been the aim to duplicate the form of the commercial manufacturing plant along with its problems of organization, production, and management. This result is not secured in all respects since the actual industrial environment is lacking, but the essential requirements of a production laboratory are established in quite definite form. In effect, the University of Illinois has a manufacturing plant, equipped with facilities, methods and materials for the production of a useful product, but without an operating organization. The latter is supplied from the ranks of students specializing in mechanical, electrical and railway engineering during their sophomore and junior years.

This group at present numbers approximately 500 men. It is untrained, but in the aggregate it represents a wealth of human talent. The instructional plan is a simple one of training this group of embryo engineers to operate the plant and produce gas engines efficiently and economically. Production is sought not for the usual commercial reasons, but as a laboratory exercise for training men in the principles of management and in the mechanical processes of production. The aim is to stimulate the spirit of leadership by placing the responsibility of operation squarely before the student. In this feature, the plan departs from the usual method of academic instruction, and in a considerable degree it fulfills the requirements previously mentioned for training that will develop leaders rather than technicians.

The Development of the Instructional Plan

Essentially the industrial process is a simple one of changing materials from one form to another by the application of power through the agency of tools, under human control and direction. Specifically, the instructional plan is developed around the theory that preparation for industrial management is accomplished through a study of the three important elements of the industrial process just mentioned: (*a*) the worker or the producing unit; (*b*) the equipment or the unit worked with; and (*c*) the materials or the unit worked upon. The meaning of these basic elements and their relation to each other is brought out by treatment of the following topics under three headings:

The Worker. Types of organization, functions of the executive, relations to industry, physical facts, effects of environment, methods of reward, costs of service.

The Equipment. Selection and specifications, maintenance methods, operation methods, planning methods, production methods, standardization methods, testing and experimental methods, and costs of production.

The Materials. Studies in construction and suitability, purchasing methods, storage methods, dispatching methods, ordering and inventory methods, transportation and delivery methods, costs of materials.

As arranged, these topics form a syllabus of the course of instruction, which has determined the details of the practical working plan, a brief description of which follows.

The Classification of the Student Body

The entire body of students previously referred to is automatically divided by registration into four groups, one to each of the main departments of the shops. Each of the department groups is subdivided into staff assistants and shop workmen. Assignments to these duties are made arbitrarily, but each student is moved periodically from one task to another so that during the entire course he performs all of the staff functions and the required mechanical, or shop, operations. The schedule is arranged so that the time is divided equally between the staff and shopwork. Duty assignments are for periods of two weeks or four weeks, depending upon the work to be covered, and they are alternated between the office and shop, according to expediency. From the performance of the duties of production assistant, a

student, in the foundry, for instance, may be found during the following work period making molds of pistons on one of the molding machines, or vice versa. At the beginning of the term demonstrations of shop operations and of staff duties are given to all students, which are expected to prepare them for any subsequent work they may be called upon to do, with the aid of carefully prepared standard practice instructions.

The staff group performs the executive and supervisory work of the plant, and the shop group serve as workmen at the bench, on machines, in the core room, at the hardening furnaces, or wherever their services are required. Job orders are issued by the staff group to the shop group, according to the requirements of the production schedule adopted at the beginning of the school term. There are four sections of students in each department operating independently on different periods of the week, which introduces considerable rivalry in the matter of output. Naturally those sections with the most effective staff work secure the greatest production and the highest shop efficiency.

There are seven distinct divisions in the staff work: production, safety, standard practice, materials, mechanical, experimental, and accounting. Every student is expected to serve the allotted time in each division, but only once throughout his entire shop course. He may obtain his training in production, for instance, in the foundry, and in standard practice after entering the machine department. He will perform, however, all of the staff functions before completing his shop course.

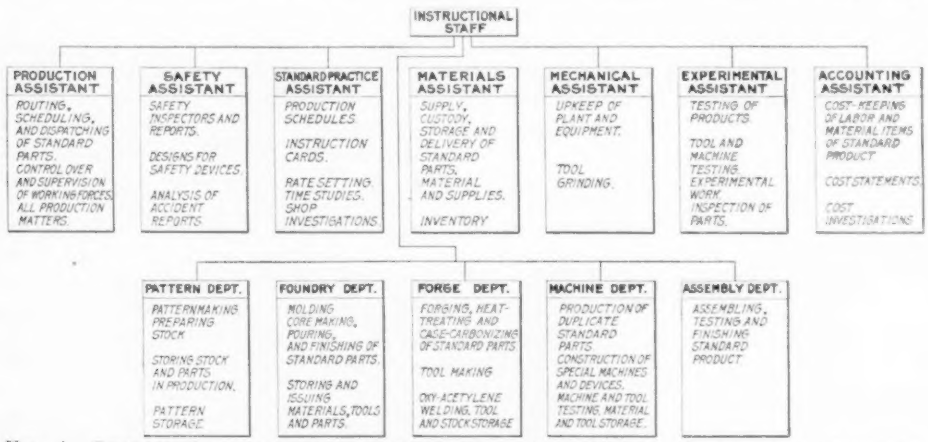


Fig. 1 General Layout of Shop-Management Courses for Engineering Students
Showing organization of student operating staff and the main features of the training in executive and administrative work; the main shop departments and the most important items of training in mechanical shop practice.

The Work of the Students

The required work in each staff division is shown by the diagram of Fig. 1, a study of which, it is believed, will substantiate the statement that the various items are fundamental in the training of engineers for the practice of industrial management. In general, the student obtains from this part of the course a rather definite impression of routing and dispatching parts through the shop, standardizing work operations, rate setting, the custody of materials and supplies, safeguarding dangerous equipment, upkeep of machinery and tools, inspection of parts, cost keeping, as well as the supervision of men engaged in the production of work.

For the conduct of staff functions, effective but simple systems embodying the use of shop records, forms and production facilities have been adopted in somewhat different detail by the various departments. Production boards are employed in this work, and the effect of graphical records such as this upon the more intelligent students is very marked. Those with inborn executive ability immediately display their special qualifications for organization and leadership by increasing output over less gifted predecessors. The records of this group of students are repeated in all departments. There is no doubt about them; they are born to lead, and they do lead, although they may not measure up to the highest academic standards in other courses.

The Departmental Organization

Departments are organized on similar lines and they administer instruction after a common plan, but the difference in character of their mechanical processes, and of the materials used, makes it possible and also advisable to vary departmental emphasis on certain features of the instruction. In the pattern department the subject of planning and work analysis is given special consideration; in the foundry and machine departments production of parts is emphasized; and in the forge department experimental work is given prominence. By this arrangement the more important factors of shop management are brought forcibly to the student's attention. As the time allotted to the shop courses is entirely inadequate for a thorough presentation of the subject of industrial management, instruction is planned to throw the important elements into bold relief with the object of creating lasting impressions of them upon the mind of the student. It follows that certain features of the work, which were formerly considered of some importance, are given no more than passing attention, but this is immaterial if the larger principles of management are effectively presented to, and thoroughly understood by, the group of future leaders.

Charts, diagrams, graphical records, and illustrations of all kinds are freely employed throughout the various stages of the instruction. It has been clearly demonstrated that facts and impressions are more easily and accurately acquired through the eye from illustrations than by any other method. In addition an effective graphical representation appeals to the imagination and stimulates the desire to work and to produce results.

As the object of the course is the training of engineers in the principles of management, the staff portion of the instruction is strongly emphasized, but not to the exclusion of the other portion relating to manual shop-work. The time devoted to each of these phases of plant operation is divided equally. A general idea of the manual operations performed during the entire course will be gained by referring to the diagram of Fig. 1. Briefly, this work includes patternmaking and preparing stock, molding, core making, pouring metals, and finishing castings, forging, heat treating and case carbonizing, machine-tool operation, assembling, finishing and testing. All of these operations are performed on standard gas-engine parts. Operations are standardized as to method and time. Jigs and special tools are employed wherever they apply. Jobs are scheduled by a staff assistant according to the production program, so the student workman must produce a given volume of work that will pass inspection if he obtains a passing grade in the course. A record of actual time on each operation is recorded by time clocks on job orders. The ratio of this time to the standard time allowed by the instruction card gives the efficiency of production of individuals on separate jobs. No attempt is made to teach students the so-called fundamental shop operations. Machine and tool operation is explained, and accurately prepared instructions for doing single jobs are issued, from which the student is expected to go ahead and produce. Generally, it may be said, that the average student does this in satisfactory fashion.

The above-mentioned plan is not perfect. Its faults, however, are superficial rather than fundamental. It is not intended to fulfill the specifications of a complete course in industrial management, nor is it expected to possess the power of developing competent executives and managers from untrained men within the period of a few weeks; but as a pioneer experiment in technical education it presents possibilities of usefulness in the development of engineering leadership which, it is hoped, will be fully realized.

Alloyed Aluminum as an Engineering Material

By G. M. ROLLASON,[1] CLEVELAND, OHIO

Upon its discovery aluminum was hailed as a panacea for all the ills of the metallurgist and its use was proposed for every imaginable purpose from armor plate to chemical chambers. But because it failed to do all that was expected of it a general distrust was created which has been very hard to live down. Recent developments, however, especially those which took place during the war, are rapidly dispelling this idea. In his paper the author first treats of unalloyed aluminum and its light alloys. He traces the improvement in the development of commercial alloys, presenting in connection therewith photomicrographs of the alloys commonly used. He also discusses the subject of the casting of aluminum as well as the methods employed in both the cold and hot rolling of the metal. The possible future uses of aluminum and its various alloys are also briefly considered by the author, who ventures the opinion that perhaps it would not be too optimistic to say that while we have passed through the Stone Age and the Bronze Age, and are now living in the Iron Age, that the future holds in store for us an Aluminum Age.

THE physical properties of aluminum which render it useful for certain general applications are well known, but its special properties and more particularly those of its alloys which render the metal useful for strictly engineering purposes are not, however, so thoroughly understood as the present diversified uses in engineering would seem to imply. At the same time, as is natural during the development of a comparatively new material, there is a tendency to expect sometimes too much and sometimes not enough.

Attempts to use aluminum under unsuitable conditions, however, are not now as prevalent as they were ten years ago. It should nevertheless, be realized that the possible field of application is limited by the specific properties of the metal. Aluminum and its alloys have their true field just as clearly indicated by their properties and price as are the fields of copper and its alloys or iron and its alloys. A consideration of the fields of application where manufactured aluminum has found its way by natural growth and scientific development will indicate those fields where its application is most legitimate.

Fig. 1 shows both the annual production of aluminum metal in the United States from 1895 to the beginning of the war period, and the total number of motor vehicles produced yearly through a period over which the increase of aluminum production has been very marked. The world's total annual aluminum production at the present time may be estimated about 300,000,000 lb.

During the war period development of aircraft was of course responsible for considerable increase in the application of light alloys. The parallel growth in the two production curves confirms the actual facts in that a very large percentage of aluminum production finds its way into automotive vehicles, which is by far the greatest field for engineering application of the metal. It is to be expected, however, that development of aerial navigation in the future will take a very large share of the increased light-alloy production.

Unalloyed Aluminum

The characteristic and dominant properties of aluminum are of course very well known, the most important being its low specific gravity. Next in importance come the relatively high conductivities, both thermal and electrical. This is true not only of the commercially pure metal, but of its light alloys, that is, those containing aluminum as their principal ingredient. In these the properties of aluminum itself, such as specific gravity and conductivity, are dominant, but the mechanical properties can be very greatly improved by alloying.

[1] Aluminum Castings Co.

Abstract of a paper presented at a meeting of the Metropolitan Section of The American Society of Mechanical Engineers, February 10, 1920.

The engineering applications of the commercially pure metal are fairly limited and somewhat beyond the scope of this paper, but the physical properties of the pure metal are interesting as a basis of comparison for those of the alloys. In the cast or annealed conditions these properties are:

Tensile strength	13,000 lb. per sq. in.
Elongation	25-35 per cent
Modulus of elasticity	8,500,000-10,000,000 lb. per sq. in.
(Cast iron, 20,000,000; machined steel, 30,000,000)	
Brinell hardness	25
Sclerescope hardness	5-6
Specific gravity	2.7
Specific electrical conductivity	61 (copper, 100)
Specific thermal conductivity at 64 deg. fahr.	116 (copper, 222)
Extreme ductility and softness make figures for compressive strength meaningless.	

The commercially pure metal in the cast condition has practically no engineering application. In the wrought or cold-worked state, however, there is of course a very large commercial use. Domestic use of spun, stamped, or rolled aluminum ware is very familiar and the characteristic lightness and heat conductivity are again the controlling properties.

Rolled aluminum sheets and drawn wire are also in extensive use. The rolled sheet is used largely in automobile bodies, gasoline tanks, etc., where the improvement in properties due to working is utilized for mechanical strength, rigidity, etc. The metal is rolled hot at about 400 deg. cent. from the ingots or slabs to a sheet ¼ in. to ⅜ in. thick and further reduction down to gage thickness is done by cold-rolling. Annealing of cold-worked aluminum, that is, recrystallization, will take place slowly at around 200 deg. cent., but for practical purposes the range is around 350 deg. cent. and higher. In addition to the rolled sheet, stamped or pressed aluminum is used in the automobile industry for fenders, beading, hoods, etc., and has found some application in airplanes and dirigibles for parts subjected to light stresses. There are, however, alloys of aluminum which are of much greater importance and possibilities than the pure metal, in particular duralumin, which will be referred to later

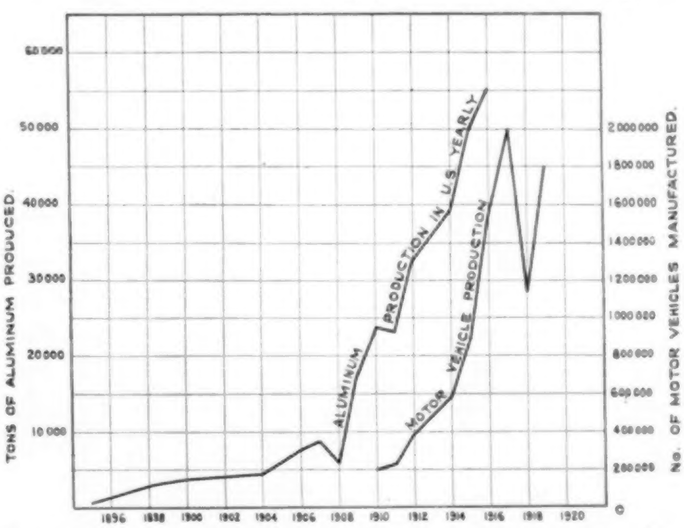


Fig. 1 Parallel Growth of Aluminum and Automotive Industries

Hard-drawn aluminum wire is used to some extent for transmission of electrical power, particularly in Europe, and by virtue of the combination of high conductivity and specific gravity. The following is a comparison of copper and aluminum wire:

	Copper	Aluminum
Specific conductivity	100	61
Cross sectional area for equal conductivity	100	164
Weight for equal conductivity	100	50
Tensile strength of hard-drawn wire	60,000	28,000

Specific gravity	8.9	2.7
Specific tenacity	6,740	10,400

The last figure, specific tenacity, is an index of comparison which has been used to some extent by English metallurgists. It simply amounts to expressing strength in terms of weight, and the figures quoted are the unit tensile strength divided by the specific gravity. The term was developed in order to provide a reasonable index of comparison for useful light alloys with more common materials. The commoner industrial metals, iron, copper, zinc and nickel, for instance, have so nearly the same specific gravity that their tensile strength can be compared section for section, but where the section can be enlarged for equal or better strength with saving in weight it is necessary to get down into more strictly comparative terms. The substitution of aluminum wire for copper has of course been influenced by the relative market prices of the two materials and has only been extensive during periods when the copper market was abnormally high.

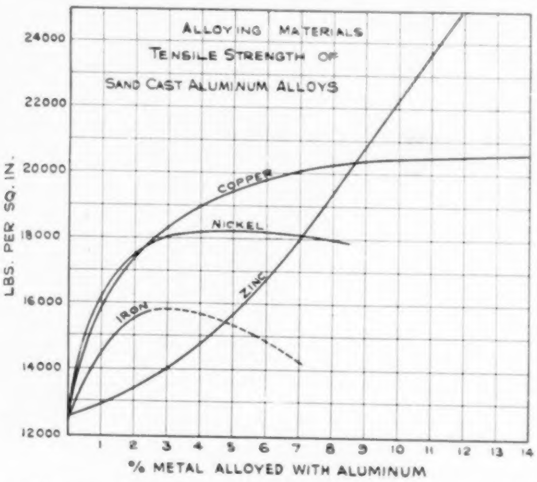


Fig. 2 Tensile Strength of Sand-Cast Binary Aluminum Alloys

With normal market conditions of the two metals, a price of 15 cents per pound for copper corresponds to 25 cents per pound for aluminum. In cases where aluminum can be substituted bulk for bulk the possibilities for the application of aluminum are therefore very obvious. There are some other applications of the unalloyed metal; for instance, aluminum is worked hot by extrusion under hydraulic pressure, the temperature used for this being about 400 deg. cent. It is fabricated in this way into structural shapes, rods and tubes, and sections up to 6 in. in diameter with wall thicknesses as small as 1/8 in. have been made. Continuous tubing may also be made by this method. This tubing finds some application in pneumatic conveyors for department-store service, also in the chemical industry where, for resistance to certain types of corrosion, the commercially pure metal gives a very satisfactory performance.

Light Alloys of Aluminum

The possibilities for engineering application of aluminum alloys are due to the fact that the lightness of aluminum can be combined in the alloys along with marked improvement of mechanical properties such as tensile strength. The term "light alloys" is one which has been finding favor during the past few years, particularly in connection with war work, and may be said to embrace those alloys having aluminum as their base and whose specific gravity ranges from 2.65 to 3.0. This division is purely arbitrary, but it is interesting to note that when there is enough heavy metal in the alloy to give a specific gravity higher than 3, the mechanical properties at the same time change to such an extent as to render the material unsuitable for many engineering purposes. The alloying of a metal lighter than aluminum, such as magnesium, will bring the gravity down below 2.65, but there are not many alloys in use where magnesium is alloyed in such an amount as to bring the gravity down without simultaneous additions of other heavier metals to produce a counteracting effect. The outside limits for aluminum alloys in commercial use are set on the light end by an alloy containing 5 per cent magnesium, with specific gravity of 2.47, and on the heavy end by an alloy containing 33 per cent zinc, with a specific gravity of 3.3.

Commercial aluminum always contains iron and silicon in amounts ranging from 0.25 per cent and upward according to the grade of ingot, and while there is a tendency to regard iron and silicon as impurities, nevertheless by their judicious control they can be made to act as useful alloying ingredients.

The commoner metals which are used to alloy with aluminum are copper, zinc, magnesium, and nickel. There are many others which have been used in aluminum-base alloys, most of which, however, have hardly passed the e perimental stage. Among these may be mentioned chromium, molybdenum, tungsten and vanadium. In general the effect of progressive additions of the alloy metals to aluminum is to render the base metal correspondingly harder, stronger, and less ductile. It should be explained that "ductile" does not refer here to the property of being easily drawn into wire, but merely to the measured percentage elongation, that is, the amount of possible deformation without fracture.

Three types of aluminum alloys are manufactured for engineering purposes, namely,

1 Casting
2 Cold-working
3 Forging or hot-working.

It is estimated that a half of the world's production of aluminum goes into castings, that is, it is used in the alloyed form, and since a large part of the unalloyed aluminum is put to miscellaneous and non-engineering uses, the majority of engineering uses and mechanical applications must consist of castings. The casting alloys will therefore be considered first.

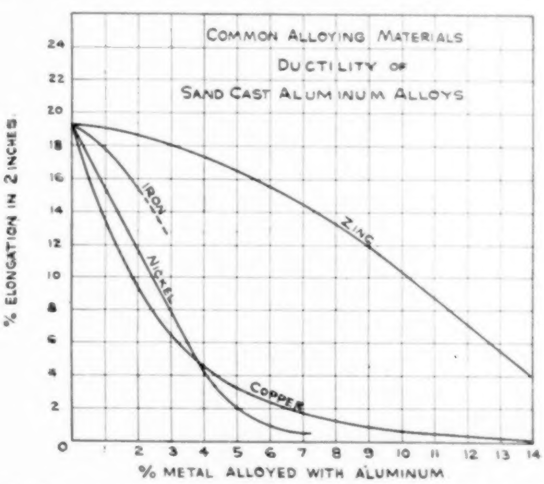


Fig. 3 Ductility of Sand-Cast Binary Aluminum Alloys

Development of Properties by Alloying

Figs. 2 and 3 show the variation in tensile strength and ductility of aluminum, cast under carefully controlled conditions, produced by progressive additions of copper, zinc, nickel, and iron as alloying ingredients. Copper gives increased strength and decreased ductility up to about 11 per cent, at which point the alloys become quite brittle. The effect of zinc is less marked than that of copper in amounts up to 8 per cent especially as regards ductility; above 8 per cent the zinc alloys continue to become stronger and less ductile after the effects of copper have practically reached their maximum. This difference in behavior of copper and zinc alloys is due to difference in structure. (See later paragraphs under the heading Metallography.) Iron gives useful strengthening properties in amounts up to 2 per cent, but above that the effects are doubtful owing to rapid rise of the melting point and other disturbing conditions. This effect of iron, unlike that of the other metals, is additive, that is, it can be superimposed on that of the other metals. Nickel in behavior is intermediate between copper and iron.

Magnesium is a valuable addition to aluminum or its alloys when used judiciously. Of all metals it has perhaps the most pronounced effects on the properties of aluminum when added in small amounts, probably owing to presence of silicon. It is a very pronounced hardener and especially if the silicon content of the aluminum ingot is high the effect of magnesium even in amounts as low as 0.1 per cent will be to render the alloy stronger, harder and more brittle.

When about 12 per cent of copper or 15 per cent of zinc is added, the specific gravity reaches about 3 and it will be noted that when this figure is reached the alloy has reached a state of comparative brittleness and low ductility which renders it not only of limited usefulness in the cast state, but incapable of being cold-worked. It will be seen that it is comparatively easy to choose mixtures for alloying composition which will give high tensile strength, but to obtain a combination of high strength and ductility it is necessary to use careful selection and to give attention to constitution. The most important alloying materials are copper and zinc; that is, for casting and working purposes aluminum-copper alloys, aluminum-zinc alloys and aluminum-copper-zinc alloys cover most of the field. At the present time the aluminum-copper alloys find a good deal of favor in this country, while aluminum-zinc alloys seem to be preferred in Europe. This condition, however, has changed from time to time, since there have been periods when aluminum-zinc alloys have been in extensive use in this country. It is probable, as investigation and development progress, that successive improvements will involve more complex mixtures.

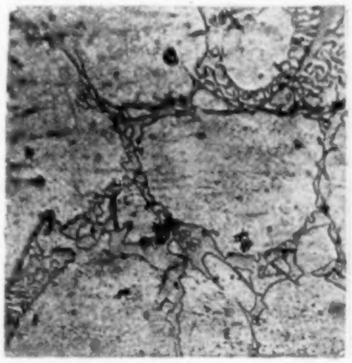


FIG. 4 TYPICAL 8 PER CENT COPPER-ALUMINUM ALLOY

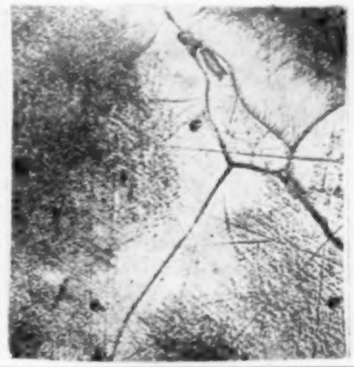


FIG. 5 TYPICAL 15 PER CENT ZINC-ALUMINUM ALLOY

FIG. 6 ALUMINUM ALLOY CONTAINING Mg_2Si COMPOUND

METALLOGRAPHY OF ALUMINUM AND ITS ALLOYS

While the development of alloys, particularly casting alloys, in the past has been more or less a matter of cut and try, the metallography of these alloys is becoming quite well understood and study of constitution is leading to the development of properties in light alloys which have not been brought out through many years of experiment under the older methods.

Fig. 4 shows a micrograph of a typical 8 per cent copper-aluminum alloy. It contains two constituents, one being the background or matrix of solid solution, that is, so-called mixed crystals of copper dissolved in aluminum; the other constituent which appears as a network around the grain boundaries is a eutectic of the solid solution and a compound $CuAl_2$. This network is very hard and brittle and serves to reinforce the alloy, making it harder and stronger. At high temperatures, just below the melting point, the solid solution will contain about 4 per cent of copper. In an alloy like this, with 8 per cent copper, the other 4 per cent goes to form the eutectic network around the grain boundaries. It is to be noticed that the network is quite complete, that is, it forms a closed structure, and since it is brittle it cuts down the ductility of the alloy, which in this case shows only about 1½ per cent elongation. Though the solid solution is more ductile and would show more deformation without break, the brittle eutectic network prevents it.

Zinc, as shown in Fig. 5, is more soluble than copper and the solid solution will contain about 40 per cent of zinc without the appearance of a separate constituent. In general appearance this alloy is quite similar to pure aluminum. The effect of the zinc is to make the crystals of solid solution stronger, but there is no separate brittle constituent with cellular structure as was the case with copper so that for a given tensile strength the zinc alloy will have a greater elongation. Fig. 6 shows the appearance of magnesium. The magnesium will form a solid solution up to a certain point and then separate out, a compound Mg_4Al_3 being formed, but since all aluminum ingot contains silicon, the result is generally somewhat different. The magnesium combines with silicon to form a compound Mg_2Si, which is practically insoluble and very brittle. Its effect is the same as that of the copper compound, but very much more pronounced; that is, an addition as low as 0.25 per cent magnesium has a marked hardening effect.

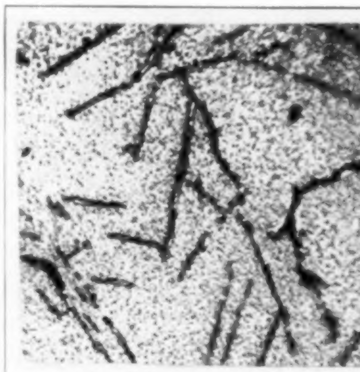


FIG. 7 ALUMINUM ALLOY WITH NEEDLES OF $FeAl_3$ COMPOUND

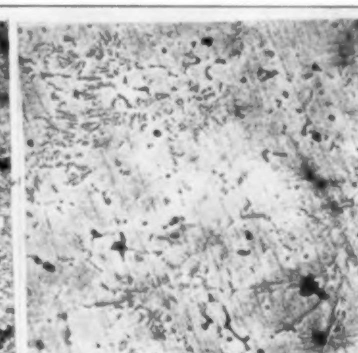


FIG. 8 ALUMINUM-COPPER-ZINC-IRON ALLOY

Iron, manganese, and nickel form compounds with the aluminum such as $FeAl_3$, which show up in the form of long needle-shaped crystals as in Fig. 7. These compounds are practically insoluble, and even a small amount of iron will cause the appearance of the needles. The effect of these needles is to break up the continuity of the copper or other network, and in the case of a break the iron needles make the path of rupture longer. In this way small additions of iron give both greater strength and greater ductility.

Fig. 8 shows a ductile casting alloy containing copper, zinc, and iron. The zinc does not show up, since it stays in solution. The copper network is just beginning to appear, since there is

about 3 per cent copper present, or just in excess of the amount which will stay in solid solution under the normal cooling conditions. The iron needles are distributed around and perform their function of giving additional strength and ductility.

Commercial Casting Alloys

The development of useful physical properties by alloying selected metals with aluminum has made possible the commercial use of a number of widely varying alloys. A good many of these are either straight binary alloys or binary alloys with very slight impurities or additions of third or fourth metal. The light aluminum alloys which are used for sand casting in America center for the most part around different copper-aluminum combinations.

The principal aluminum alloy used for castings in the United States consists of about 92 per cent aluminum and 8 per cent copper, and is generally known as Aluminum Company of America's No. 12 alloy or S. A. E. specification No. 30. This alloy when cast in a ½-in. test bar in green sand and tested without machining off the skin should give an average tensile strength of about 20,000 lb. per sq. in. and an average elongation of about 1.5 per cent in 2 in. A modification of this alloy having somewhat better physical properties is now finding considerable favor in castings for the automotive industry. This alloy has an analysis of 7.5 per cent copper, 1.5 per cent zinc, 1.2 per cent iron, and the remainder aluminum. The tensile strength of this alloy will average about 21,000 lb. per sq. in. and the elongation will be somewhat greater than that of the No. 12 alloy.

Where greater ductility is required the copper content is cut down to about 5 per cent, resulting in a tensile strength of about 18,000 lb. per sq. in. and an average elongation of 3 per cent. This alloy is used for castings such as those for automobile bodies which require to be pressed or bent into their final shape. This alloy is somewhat more difficult to cast than No. 12, due to the lower copper content and consequently higher shrinkage.

Another alloy which is well known under the designation S. A. E. Specification No. 32, contains approximately 12 per cent copper and remainder commercial aluminum. The high content of copper renders it somewhat easier to cast, as it cuts down the solidification shrinkage of the alloy and makes in general for denser and sounder castings. As a result of this the alloy is selected for use in castings where tightness against leaking is the principal requirement. It has the disadvantage of being quite brittle, due to the large amount of copper constituent present. The casting fails to show a marked improvement in tensile strength over the common 8 per cent copper alloy owing to the fact that in the structure of the latter the reinforcing network of copper compound is completely closed (See Fig. 4), and no further strengthening is produced by the excess amount given when the copper is increased up to 12 per cent.

As previously mentioned, there is a tendency in Europe, and especially in England, to favor the zinc-aluminum combinations, and the alloy which corresponds to our No. 12 is known as L-5 and contains 13.5 per cent zinc, 2.75 per cent copper and the remainder commercial aluminum. This has a specific gravity of about 2.95, or higher, which is relatively high as compared with No. 12 alloy at a specific gravity of 2.83. Its tensile strength when cast in sand is over 25,000 lb. per sq. in., but the elongation is not much over 1 per cent.

Another alloy which finds favor in England contains 10 per cent zinc and 2.5 per cent copper. Here some ductility has been gained over L-5, that is, it gives over 2 per cent elongation, but at a sacrifice of tensile strength, since the specification only calls for 22,000 lb. per sq. in.

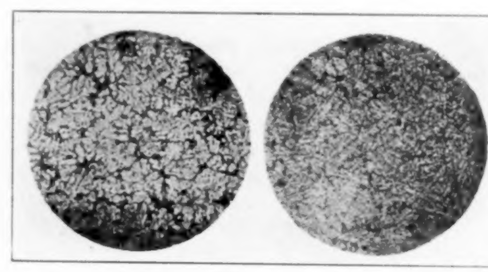
The foregoing are some of the aluminum alloys most widely used in sand castings. There are, however, a few special uses which demand special alloys; for instance, commercially pure aluminum, in general, is much less subject to corrosion than any of its alloys, but in cast form is too soft for much practical use. In this connection an alloy of 98 per cent commercial aluminum and 2 per cent manganese finds some application, that is, it resists corrosion practically as well as the unalloyed metal, while the small addition of manganese gives the necessary strength and hardness in the castings.

Permanent-Mold Castings

By far the greater part of the cast aluminum used is in the form of ordinary sand castings, although a considerable tonnage of aluminum is manufactured in permanent molds. In this country the manufacturers of aluminum castings in permanent molds have not so far undertaken the casting of very large pieces, but castings up to 150 lb. in weight have been made in chill molds on a semi-commercial scale.

The chill-cast aluminum finds its principal outlet in the form of gas-engine pistons and this has led to the development of specialized alloys. Permanent molding, though a much newer art than sand casting, is susceptible of more scientific control and actually approaches a more exact science. The feasibility with which any alloy can be cast into a chill mold depends upon the simplicity of the desired casting design, and for casting complicated shapes the alloy selected should be such that its solidification shrinkage is relatively small.

For the permanent-mold casting of fairly intricate shapes such as aluminum pistons, bearing caps, etc., an alloy containing 10 per cent copper, 1.5 per cent iron and 0.25 per cent magnesium, remainder commercial aluminum, is used fairly extensively. This has the property of running well in permanent molds, the shrinkage being kept low by the relatively high percentage of copper. Fig. 9 shows the difference in structure obtained by casting this alloy in a permanent mold and in sand. It gives a fine-grained, dense structure with high strength and hardness, making it suitable for wearing or bearing surfaces and easy to machine. In a properly made chill casting this alloy will have a tensile strength of 28,000 lb. per sq. in. and 2 or 3 per cent elongation, but these properties can only be attained by careful attention to all the factors going to make up a good casting.



Cast in Green Sand   Cast in Permanent Mold

Fig. 9 Sand- and Chill-Cast Piston Alloy

Table 1 enumerates the properties of some of the alloys whose composition has been given above.

TABLE 1 PROPERTIES OF CERTAIN ALUMINUM ALLOYS

	No. 12	S.A.E. 32	British L-5	Lynite 145
Tensile strength, lb. per sq. in.	20,000	20,500	25,000	27,500
Elongation, per cent	1.5	0.5	1.5	4.5
Brinell hardness	65	70	80	65
Scleroscope hardness	14	16	18-20	14
Specific gravity	2.84	2.90	2.92	2.89

Stress-Strain Characteristics—Value of Ductility

In the selection of a casting alloy for certain applications, ductility must rightly receive consideration. For parts which are subjected to normal stress, rigidity and a reasonable amount of strength are the only essentials. In many cases the factor of safety is also very high, since the dimension of the cast piece is controlled by ability to cast or manufacture—for example, the

familiar aluminum crankcase casting. However, where a cast-aluminum member is designed for a heavily stressed part the resistance to normal stress is not the only matter to be considered. The factor of safety might be made such that the ordinary stress range could be taken care of, but if this were exceeded and there were no ductility in the material, complete failure would be the result. It is in connection with abnormal stresses in engineering parts and with abuse as opposed to normal use that ductility must be regarded as a very valuable and essential property for cast aluminum or similar engineering materials. There are also cases where, apart from the performance of the finished part, ductility is absolutely essential to the process of manufacture. Sand castings must of necessity have liberal tolerances for the dimensions. With these variations assembling of parts will involve some rough handling and knocking together and there are instances on record where assembling shops could not use the ordinary brittle aluminum alloys when it was attempted to substitute aluminum for bronze castings, but where a ductile aluminum alloy of high strength met with good success.

In general it may be said that the cast aluminum alloys are not very elastic materials, that is, if the proportionality of stress to deformation is considered to be the test of elasticity. However, though the proportional limit of cast aluminum alloys is low, the yield point is relatively high and in comparing the stress-strain curve of a cast aluminum alloy with that of machine steel, for instance (see Fig. 10), there is a range of relatively high stress, about 13,000 lb., for aluminum alloy and 34,000 lb. for the steel when both have taken on small amounts of permanent deformation, but at this point for further slight deformation of the aluminum alloy it is necessary to put on a relatively large additional stress, while the steel will deform greatly under quite a small additional stress.

The fatigue life of ordinary aluminum alloys under repeated reversal of stress (White-Souther test, for example) is not very well recorded. The performance, however, in such few tests as are on record seems very promising. There appears to be a safe working range well above the proportional limit. For instance, in ordinary No. 12 alloy the proportional limit is around 5000 lb. per sq. in. and tensile strength about 20,000 lb. per sq. in., but this alloy has shown a fatigue life of 16,000,000 reversals under a stress of 8500 lb. per sq. in. Machine steel, on the other hand, for a life of 16,000,000 cycles will take a stress of only 11,000 lb. per sq. in. when its tensile strength is over 60,000 lb. and its proportional limit correspondingly higher than that of the aluminum alloy. The fatigue properties of the aluminum alloys, however, are not thoroughly accounted for as yet, and while such results as the above have been obtained, there are only a limited number of them on record. In accounting for such performance it might perhaps be explained in terms of structure by the fact that the aluminum alloy is a combination of brittle and ductile materials, and whereas in the straight tensile pull the brittle materials are pulled out of place with a relatively small amount of total deformation and their strengthening effect is lost, under the reversal of stress in the fatigue test these constituents remain in their original position and the alloy retains the benefits of their presence.

Possible Extensions of the Engineering Application of Aluminum

The automotive field at the present time forms by far the largest engineering outlet for aluminum alloys. There are some possible applications which are based very specifically on the properties developed in aluminum alloys which may be mentioned, but these possibilities at the present time are not to any extent realized. For instance, in any kind of light high-speed machinery the inertia of reciprocating parts and consequent vibration and shocks can be cut down by judicious substitution of aluminum alloys for heavier materials provided their physical properties are properly understood and can be relied upon. Also in high-speed pulleys where centrifugal stresses run high, cast aluminum can be substituted for cast iron to good advantage.

Where rigidity is the prime consideration, the figures controlling the substitution of aluminum for ferrous materials are interesting. The modulus of elasticity of aluminum and its alloys may be taken as 10 million lb. per sq. in. with gray iron at 20 million and machine steel at 30 million. The rigidity is proportional to the modulus of elasticity and to the section modulus. To substitute aluminum for gray iron with equal rigidity, therefore, the section modulus must be doubled, and this can be done with a 50 per cent decrease in weight for a cross-section of equal rigidity.

The Working of Aluminum and Its Alloys

Aluminum alloys are not used to any great extent for cold-working. Cold-worked aluminum is nearly always unalloyed aluminum. The more ductile alloys are fashioned and shaped to some extent in the cold, for instance, in automobile body work, and during the war a very large number of fuse bodies for shrapnel were made by cold-stamping an aluminum alloy containing 3 per cent copper.

The rolling, drop forging and general hot-working of aluminum

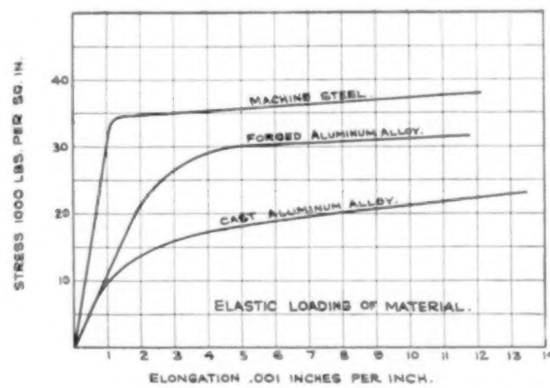


FIG. 10 STRESS-DEFORMATION CURVES OF ALUMINUM ALLOYS AND MACHINE STEEL

alloys have recently undergone considerable development and this has been largely due to development of particular alloys. At the present time the most remarkable alloy of aluminum is undoubtedly duralumin, which was developed in Germany by A. Wilm in 1903. A series of patents originating in Germany were brought out from the years 1903 to 1914. This alloy is notable for the fact that while it is fabricated in the hot condition, that is, well above the lowest annealing temperature, its final metallurgical condition and properties are controlled and improved by heat treatment and are very different from what the alloy composition gives in the cast or simple annealed form. Duralumin came into a good deal of prominence due to its extensive use in aircraft during the war. It was used to a large extent for framework and joints on dirigibles, being rolled and formed into structural shapes and extruded into tubes and sheets and a large number of other uses. The composition of the alloy varies somewhat, but the elements essential to the development of the characteristic properties are copper in amounts of 3.5 to 5.5 per cent and magnesium from 0.50 to 1 per cent. Additions are also made of such elements as iron or manganese in small amounts and even in some cases chromium or molybdenum.

In the manufacture of duralumin parts the general cycle of operations consists of:

1 Pouring of the ingots
2 Hot-rolling to a slab or bar
3 Hot-working to the final shape
4 Heat-treating and quenching
5 Aging.

The ingots are poured with the metal at as low a temperature as possible, that is to say, just enough above the melting point to prevent cold shuts, a special type of tilting ingot mold being used. The ingot is then hot-rolled to a slab or bar for final working, the temperature being kept with advantage pretty close to 500 deg. cent. The final fabrication may be made by hot-rolling,

hot-forging, hot-stamping, etc., according to the nature of the shape it is desired to produce. These operations are carried out within a carefully controlled temperature range, between 450 and 500 deg. cent. and the material is carried to its final shape.

The hot-worked material is possessed of properties greatly improved over what would show in the cast ingot, but the full development of its usefulness is only obtained by a specific heat treatment. The alloy is heated to a temperature of 500 to 540 deg. cent. for a period of ½ to 1½ hr., depending upon the size of the piece, and immediately quenched in cold water.

After this heat treatment and quenching the properties are still further improved, but are not fully developed until a process of aging is gone through. During the aging the alloy takes on a further increase of tensile strength and elongation. This aging is analogous to what takes place with the cast aluminum-copper alloys, but its effect is much more pronounced. The very best properties can perhaps be produced after heat treatment by an artificial accelerated aging at elevated temperatures around 150 deg. cent. As an example of the manner in which the properties are developed by the various stages of manufacture, the following are fairly representative figures of an alloy of general duralumin composition: The chill-cast ingot shows a tensile strength in the neighborhood of 30,000 lb. per sq. in. and elongation below 8 per cent. After rolling, hot-forging and annealing, the tensile strength runs from 45,000 to 50,000 lb. and the elongation from 10 to 20 per cent. The exact balance between strength and ductility at this point depends upon the temperature at which the working is finished, that is upon the amount of cold work put on to the piece. After heat-treating at 500 deg. cent. or above and quenching, the properties show a marked increase: 55,000 to 60,000 lb. per sq. in. tensile strength, and 25 to 30 per cent elongation. On a freshly quenched piece these figures would not be so high, but they develop after aging for two or three weeks. If the heat-treated material is given an artificial aging by exposure to a temperature of 150 deg. cent. for 48 hr. the tensile strength will be from 2000 to 5000 lb. higher than what is obtainable by natural aging. Extensive investigations have been carried out at the United States Bureau of Standards and elsewhere on the structural and other reasons controlling development of properties by working, heat treatment and aging and a fairly satisfactory explanation has been arrived at. Metallographic considerations would show that the changes brought about are due in general to the change in solubility of the copper-aluminum compound as the temperature is lowered from 500 deg. cent. to ordinary temperatures.

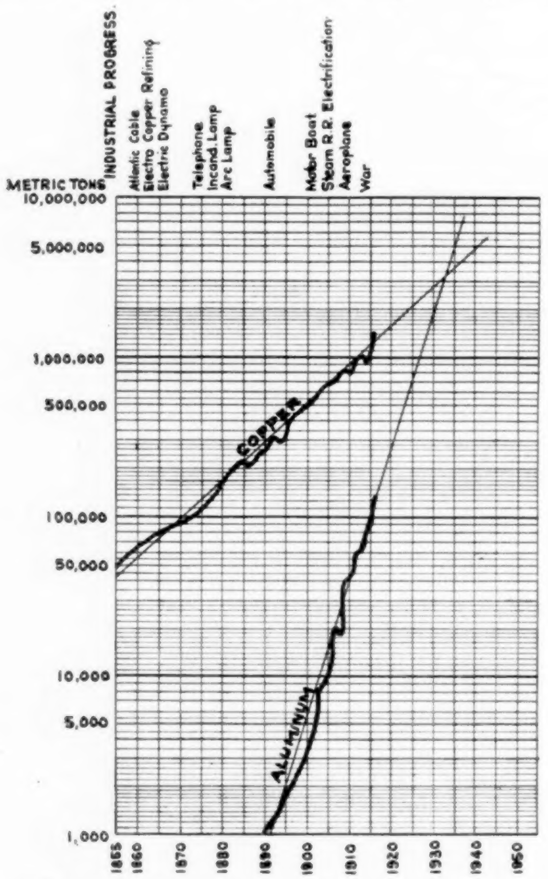


Fig. 11 World's Production of Copper and Aluminum Plotted Logarithmically to Show Relative Rates of Growth

The Applications of Duralumin

The possibilities for applications for an alloy of these properties and low specific gravity are of course very numerous. The rolling of structural shapes and of frameworks for permanent or portable structures has an immediate future. Drop-forged duralumin is finding its way into use in the automotive industry in the form of connecting rods, rocker arms, etc., as well as gears. Forged duralumin connecting rods have been submitted to prolonged test in special testing machines and in the motor on the block and on the road.

The fatigue life of the metal is very favorable indeed. A sample connecting rod made for use in a standard passenger car was run in a special machine consisting of a motor-driven crank and weighted crosshead. The speed was about 1500 r.p.m. and the load on the crosshead would correspond with about 50 per cent overload on the motor. The duralumin rod gave a life of 353 hr. and was still functioning when a casting on the crosshead failed in fatigue. A standard drop-forged steel rod for the same car showed a life of only 25 hr. under the same conditions, for example, with 50 per cent overload and another between 40 and 50 hr. at normal load both the steel rods failing in fatigue at the big end. The steel rod was of smaller section, but about double the weight of the forged aluminum rod. Some of these rods also have stood up well in block and road tests in the motor to the extent of over 10,000 miles of running. A notable feature of a number of these tests has been that at the big end bearing, the rod has been run direct on the crankshaft without any bushing whatsoever. Forged and heat-treated duralumin, in fact, is showing up as a very satisfactory bearing material when the wear is against a sufficiently hard shaft. Rods have been run against both case-hardened and heat-treated shafts. Owing to the relatively high expansion of the aluminum alloys, however, it has been found necessary to allow a little more end play at the big end bearings than is standard practice with steel rods.

The immediate future is going to tell considerably more about the actual performance of these and other applications of duralumin. Credit must be given the inventor of this alloy for having worked it out from fundamental scientific facts, and from the spectacular point of view this alloy represents a great achievement in developing properties in aluminum by alloying. In this case aluminum with a strength of 13,000 lb. has produced an alloy with a strength of over 60,000 lb. without loss of ductility, but the specific gravity has been increased less than 10 per cent. What other similar possibilities may lie in the future it is not safe to say, but let us remember the short space of time that has been spent in reaching even the present state of alloy development. A picture which is fairly familiar to the aluminum industry is that when we speak of the beginnings of iron or bronze or most other commercial alloys we go back thousands of years to prehistoric times, but when we speak of aluminum we go back as far as our own generation only. The abundance with which aluminum occurs in nature and the reception which the engineering world has given it insure a rapidly increased production for years to come.

Fig. 11 shows the history of the annual rates of production of copper and aluminum. By the use of logarithmic coördinates and by extrapolation the prediction can be made that somewhere about 1935 or 1940 the yearly production of aluminum will equal that of copper and afterward exceed it. Perhaps it would not be too optimistic to say that while we have passed through the Stone Age and the Bronze Age and are living in the Iron Age, the future holds in store for us the Aluminum Age.

Some Applications of Alloy Steels in the Automotive Industry

By H. J. French,[1] Washington, D. C.

The following paper deals with the application of various types of nickel-chromium steels in the automotive industry. Particular reference is made to the uses of steel containing 1 per cent nickel and 1 per cent chromium and also 3 per cent nickel and 3 per cent chromium. Data are also given for these two steels showing the tensile properties and hardness developed in small-size rounds subjected to varying heat treatments. A somewhat detailed mention is made of nickel-chromium steels and treatments used for gears and airplane-engine crankshafts. General specifications governing this latter part for both rotary and stationary engines are also given, and important difficulties frequently met with in the production of crankshafts are noted. "Streaks" and "temper brittleness," both encountered in the use of nickel-chromium steels, are briefly discussed and curves showing the tensile properties and hardness of "stainless steel" under varying oil-quenching and tempering treatments are presented. There are also shown the results of cutting tests made with cast high-speed-steel milling cutters and a comparison is given with high-speed cutters made by present-day ordinary methods. Micrographs are included to show the refractory nature of the carbide in cast high-speed steel.

ALLOY steels are very widely used in the automotive industry both in the manufacture of airplanes and automobiles, and without doubt have been one of the leading factors in the development of the industry. Adequately to present this subject, however, would require more space than is here available, and so this paper has accordingly been limited to a discussion of structural nickel-chromium and carbon-chromium steels. The results of a test of a cast high-speed steel cutter are also given because of the interest of all engineers in efficient cutting media.

Some common types of nickel-chromium steels having varied applications in automotive work are given in Table 1. The nominal percentages of the alloying elements are shown and the seven steels listed constitute a highly interesting series. They find use in production of such parts as axles, connecting rods, crankshafts, gears, steering knuckles, high-tensile bolts, and a variety of small parts either forged or machined from hot- or cold-rolled or drawn bars.

In general, as the alloy contents of this series increases more care in working and treatments is required, but under suitable conditions of manufacture a variety of properties may be obtained.

Steels containing nickel and chromium in the ratio of 2 to 1 seem to be in greatest favor, but any of the steels listed are capable of developing excellent combinations of strength and ductility greatly superior to plain carbon steels of similar carbon content. Steel No. 1, Table 1, will serve as a good example for discussion.

1 Per Cent Nickel and 1 Per Cent Chromium Steel

This steel, containing approximately 0.40 per cent carbon, 1 per cent nickel and 1 per cent chromium, was largely used in the production of various parts of a well-known rotary engine under widely different physical specifications. Three such parts with the tensile requirements and heat treatments used are listed in Table 2.

While both cams and valve lifters were of small size, the use of this steel for the former is not recommended, for it is exceedingly difficult to meet the severe requirements of the specifications. However, several thousand cams made of this steel were successfully treated and, according to all available information, proved entirely satisfactory in service, but the desired properties and uniformity as shown in Table 3 were obtained only under most closely controlled conditions. The steel used was produced in the electric furnace, and the parts were small, enabling treatments to be carried out in small electric heating units. Attention is called to this because there is without doubt a great deal of high-alloy-content steel used where cheaper and lower alloys would equally well serve the purpose, though under conditions

TABLE 1 NICKEL-CHROMIUM STEELS

No.	Carbon, per cent	Nickel, per cent	Chromium per cent	Ratio, Nickel to Chromium
1	0.10–0.50	1.00	1.00	1 to 1
2		1.25	0.60	2 to 1
3		2.00	1.00	2 to 1
4		2.50	1.25	2 to 1
5		3.00	1.00	3 to 1
6		4.00	1.00	4 to 1
7		3.00	0.50	6 to 1

TABLE 2 NICKEL-CHROMIUM STEEL

Carbon, 0.40 per cent, nickel, 1.0 per cent, chromium, 1.0 per cent

Part	Requirements			Heat Treatment (All parts normalized before machining)
	Ultimate Strength, lb. per sq. in.	Yield ratio, minimum	Elongation in 2 in., per ct	
Connecting Rods	145,600 to 156,800	0.75	18 to 15	[1]1550 deg. fahr.—oil [2]950-1000 deg. fahr.—oil
Valve Lifters	190,000 to 202,000	0.75	14 to 12	1525 deg. fahr.—oil 780 deg. fahr.—oil
Cams	247,000 to 268,000	Not specified	12 to 10	1525 deg. fahr.—oil—Tempered 30 min. in oil at 380 deg. fahr.

[1] Quenched in oil from 1550 deg. fahr. [2] Tempered at 950 to 1000 deg. fahr. and quenched in oil.

TABLE 3 HEAT-TREATED NICKEL-CHROMIUM STEEL

Composition (per cent). C, 0.420; Mn. 0.400; Si, 0.170; P, 0.024; S, 0.031; N, 1.120; Cr, 1.00. Size: Approx. 0.4 in. diam.

Ultimate Strength, lb. per sq. in.	Elongation in 2 in., per cent	Reduction of Area, per cent	Brinell No.
261,500	11.5	44.2	555
256,100	11.5	46.7	495
259,000	11.5	47.8	555
260,800	11.5	47.1	512
263,700	12.5	47.1	512
261,700	11.6	41.2	512
263,200	12.0	47.1	555
259,000	10.0	46.7	512
267,700	11.5	43.5	512
For 9 tests			
267,700 (max.)	12.5	47.8	555
256,100 (min.)	10.0	41.2	495
261,430 (avg.)	11.4	45.7	524

[1] Met.E.; Metallurgical Division, Bureau of Standards, Washington, D. C.

Presented at a meeting of the Washington Section of The American Society of Mechanical Engineers, March 31, 1920. Published by permission of the Director, Bureau of Standards.

not as severe as those cited, thereby saving considerable expense to the industry.

The tensile properties and hardness of this steel in small sizes under varying but single heat treatments are shown in Fig. 1. Variation in tempering temperatures between about 650 and 1350 deg. fahr. gives a variation in properties approximately as follows:

Yield point, lb. per sq. in.	200,000	to	85,000
Tensile strength, lb. per sq. in.	220,000	to	117,000
Elongation in 2 in., per cent	11.5	to	25.5
Reduction of area, per cent	45	to	72
Brinell hardness	440	to	220
Shore hardness	60	to	32

3 Per Cent Nickel and 1 Per Cent Chromium Steel

Steel containing about 3 per cent nickel and 1 per cent chromium, or often somewhat lower percentages of this element, is used for crankshafts, connecting rods, etc., when higher combinations of strength and ductility are required than may be developed in the steel previously discussed. The tensile properties and hardness of such steel containing about 0.25 per cent

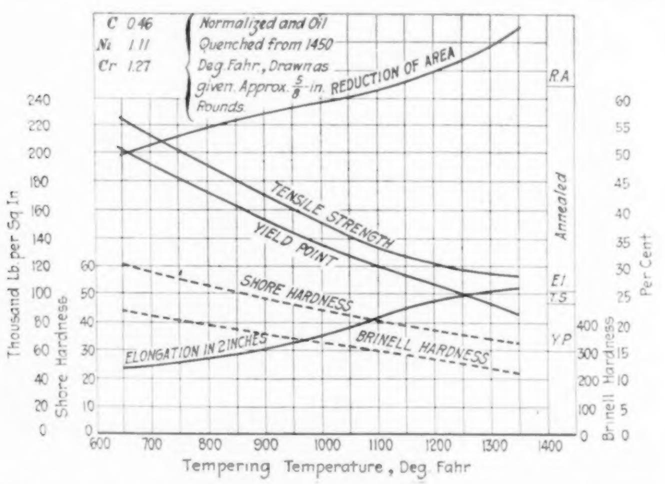


Fig. 1 Tensile Properties and Hardness Numbers of a Heat-Treated 1:1 Nickel-Chromium Steel

carbon when subjected to various single heat treatments, are shown in Fig. 2. The approximate variation in properties obtained by varying the tempering temperature between about 450 and 1300 deg. fahr. follows:

Yield point, lb. per sq. in.	190,000	to	87,000
Tensile strength, lb. per sq. in.	220,000	to	117,000
Elongation in 2 in., per cent	14	to	26
Reduction of area, per cent	55	to	70
Brinell hardness	440	to	240

If comparison of these values with those given for the 1-to-1 nickel-chromium steel is made it must be remembered that the higher-alloy steel contains much less carbon.

Crankshafts

The question of crankshafts for which this steel as well as others are used is one of such importance, especially for airplane engines, that discussion from the standpoint of the part itself now appears justified.

Despite the variety of design in both engines and parts, crankshaft specifications for most types of airplane engines may be grouped into two classes, as shown in detail in Table 4. There are exceptions to the values as given, but the table generally applies. Ordinarily the crankshaft requires skilled metallurgical control in all stages of manufacture and the best steels and treatments are none too good. The treatments used to develop the required physical characteristics vary, but with the steels ordinarily used a relatively high temperature—tempering above 1000 deg. fahr. is necessary, which is of course desirable. Both water and oil quenching are used, as shown in Table 5, which also shows analyses, treatments and properties obtained on several types of crankshafts. Where water quenching is used the shafts are usually removed from the bath after a given length of time and before they are cold, and immediately tempered to avoid cracking.

It is essential that the crankshafts be thoroughly annealed after forging and before machining in order to minimize distortion which sometimes occurs during the machining operations. Cold setting after heat treatment also gives trouble and in such cases the crankshafts should be rough-machined before heat treatment. Hair-line seams or streaks and "blue brittleness" are two additional factors which, while they are often encountered in production of crankshafts, are general and will be briefly discussed later.

In order to avoid such difficulties, care in melting, working, and thermal treatments is required. Acid open-hearth or cold-melt electric is undoubtedly the best steel to use. Excessive aluminum additions should be avoided and casting temperatures should preferably be under pyrometric control. Sufficient discard should be made to remove segregation and pipe, the amount depending upon casting practice, and all ingots and blooms should be carefully surfaced. The steel should be worked sufficiently so as to remove all traces of cast structure and heating whether for forging or heat treatment should be slow and uniform.

Heat-Treated, Cold-Drawn Nickel-Chromium Steel

Nickel-chromium steels have also found application in their heat-treated, cold-drawn condition where close adherence to size as well as high physical characteristics are required. Such steel is particularly useful in production of parts carrying threads

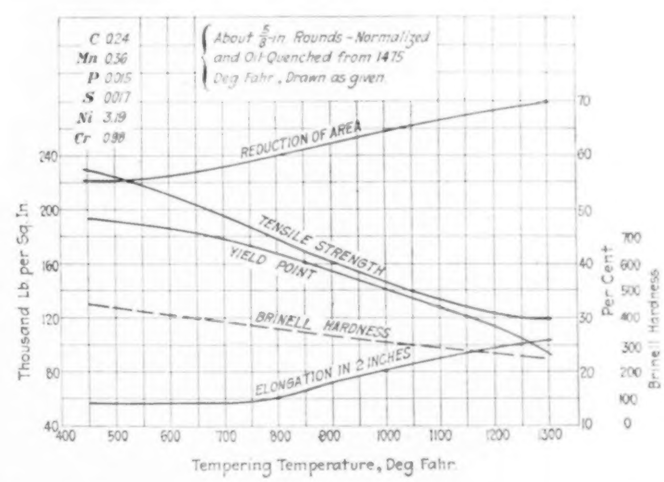


Fig. 2 Tensile Properties and Hardness Numbers of a Heat-Treated 3:1 Nickel-Chromium Steel

where oxidation from heating after machining is objectionable. Ordinarily the bars are hot-rolled to a size close to that desired and then either normalized or quenched and tempered after which they are cold-drawn. Table 6 illustrates such drawing practice and shows the effect of cold work on the tensile properties. Increase in elastic limit and tensile strength with decrease in ductility as measured by elongation and reduction in area results. Heavy final cold reductions induce brittleness and should be avoided, and in addition impair machining qualities.

Gears

Nickel-chromium steels of various analyses are also widely used for gears. The type of steel recommended depends largely upon the service desired and this, of course, together with the analysis chosen influences the treatment. The steels used, however, may be divided into two groups, viz: (*a*) tempering steels and (*b*) case-hardening steels. Typical analyses of these two classes are shown in Table 7.

TABLE 4 CRANKSHAFT FORGINGS FOR AIRCRAFT ENGINES

Percentage Composition					Physical Properties				
C	Ni	Cr	P	S	Ultimate Strength, lb. per sq. in.	Yield Ratio, Minimum	Per Cent Elong. in 2 in., Min.	Per Cent Red. of Area, Min.	Min. Impact Values–Izod 120 ft-lb. machine
STATIONARY ENGINES									
Max. 0.36	Max. 4.00	0.50 to 1.30	Max. 0.045	Max. 0.05	[1]132,000 to 157,000	0.75	17	44	35
ROTARY ENGINES									
Max. 0.35	Suitable proportions		Max. 0.045	Max. 0.05	106,000 to 128,000	0.75	17	50	40

[1] For each 4500 lb. increase above the minimum ultimate the required Izod minimum is reduced 1 ft-lb.

TABLE 5 CRANKSHAFT STEELS AND TREATMENTS

Engine	Specifications	Yield Point, lb. per sq. in.	Tensile Str., lb. per sq. in.	Per Cent Elong. in 2 in.	Per Cent Red. Area	Brinell Number	Impact, ft-lb.
A	Carbon . .0.35 per cent Manganese. . .0.61 per cent Nickel. . 3.09 per cent Chromium. 0.50 percent Normalized. 1600 deg. fahr. 1550 deg. fahr. oil 1030 deg. fahr. oil	131,250 139,400	137,350 147,400	20.0 17.5	59.0 56.3	286 302	
B	Carbon. . 0.48 per cent Manganese. . . 0.69 per cent Nickel. . 1.74 per cent Chromium. 0.85 percent Normalized. 1450 deg. fahr. Drawn. 925-1125 deg. fahr.	127,700 124,500 130,350	143,150 141,000 145,700	20.0 20.5 18.5	58.8 56.4 57.2	302 302 302	Izod 120 ft-lb. machine 47 46 46
C	Carbon. 0.35-0.45 per cent Manganese. 0.50 - 0.80 per cent Nickel. . 1.00 - 1.50 per cent Chromium. . 0.45 – 0.75 per cent.	107,500 117,600	125,500 132,200	22.0 22.0	61.6 58.7	286 286	Olsen machine 99 99

TABLE 6 HEAT-TREATED, COLD-DRAWN NICKEL-CHROMIUM STEEL

Composition (per cent); C, 0.37; Mn, 0.68; Ni, 1.60; Cr, 0.59; P, 0.010; S, 0.034.

Size, in.	Treatment	Elastic Limit, lb. per sq. in.	Ultimate Strength, lb. per sq. in.	Elongation in 2 in., per cent	Reduction of Area, per cent
1-11/32	1540 deg. fahr. oil, Tempered 930 deg. fahr.	87,650	109,400	23.2	65.7
1-5/16	Cold - drawn 1/32 in.	108,300	140,800	19.0	57.1
1-11/32	1540 deg. fahr. oil, Tempered 930 deg. fahr.	86,200	104,800	24.5	66.1
1-5/16	Cold - drawn 1/32 in.	108,200	125,900	20.0	61.3

TABLE 7 PERCENTAGE ANALYSES OF NICKEL-CHROIMUM GEAR STEELS

	C	Mn	Ni	Cr
Tempering Steels	0.50	0.45	1.75	1.00
	0.50	0.60	3.00	0.75
	0.40	0.45	3.50	1.25
	0.30	0.45	4.50	1.50
Case-Hardening Steels	0.15	0.45	1.25	0.60
	0.15	0.45	1.75	1.00

The treatment of the first class, comprised of tempering steels, is similar to treatments previously outlined and consists in normalizing or annealing the blanks before machining, after which the gears are quenched and then tempered at comparatively low temperatures (about 500 deg. fahr.). High hardness and strength together with fair ductility can be obtained.

The second class mentioned, comprised of low-carbon case-hardening steels, requires different treatment. The machined gears are carburized in suitable carburizing material and then usually double-quenched for refinement of core and of case. The result is a material of dual nature. The core, low in carbon, has high ductility and relatively low strength, while the case, high in carbon, is extremely hard and has little ductility.

Where the highest combination of strength and ductility is not essential the gears may be carburized at somewhat lower temperatures but above the critical ranges of the steel under treatment, and then quenched but once for hardening the case. With such treatment the coarse structure of the core produced during carburization still remains but a hard wearing surface is obtained.

In general tempering steels are applicable to clash gears while the higher hardness obtained in the case of the case-hardening steels makes them admirably suited for constant-mesh gears. Both types are used interchangeably, however.

HAIR-LINE SEAMS

Two phenomena encountered in the use of nickel-chromium steels which warrant discussion are "hair-line seams," also called manganese sulphide streaks, slag inclusions, etc.; and "blue brittleness," referred to as "Krupp Krankheit" and more properly termed "temper brittleness."

The first is in many instances undoubtedly due to inclusions in the ingot and consists of manganese sulphides or silicates. Probably iron silicate and iron and possibly nickel sulphides are also present. These streaks or cracks, which are not to be confused with quenching cracks, vary in depth, length and in numbers, but are most frequently present at the surface of the finished

forgings. Often removing some surface metal will cause them to disappear, only to be replaced by others, whereas sometimes the removal of a small surface layer will cause them to disappear entirely. This suggests that in some cases they may originate by being driven in from the outer surface during forging. It is therefore good practice to leave more than the ordinary amount of metal for finish-machining. However, their absence from the finish-machined forging is no proof that they do not exist in the interior. Whether such streaks are deleterious is open to discussion, but in the writer's opinion they should certainly be regarded with suspicion when present in considerable numbers, particularly if at or near sharp corners in machined forgings subjected to high stresses.

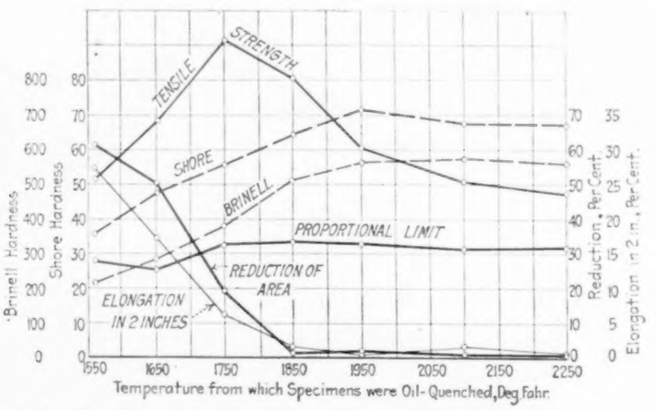


Fig. 3 Effect of Varying Quenching Temperature on the Physical Properties of a High-Chromium Steel

Temper Brittleness

The second phenomenon mentioned is evidenced in the low impact values obtained in slow cooling from the tempering heat, between temperatures of 400 to 1100 deg. fahr., and more particularly 700 to 1000 deg. fahr. By quenching from these tempering temperatures, normal impact values are obtained. Table 8 illustrates this effect.

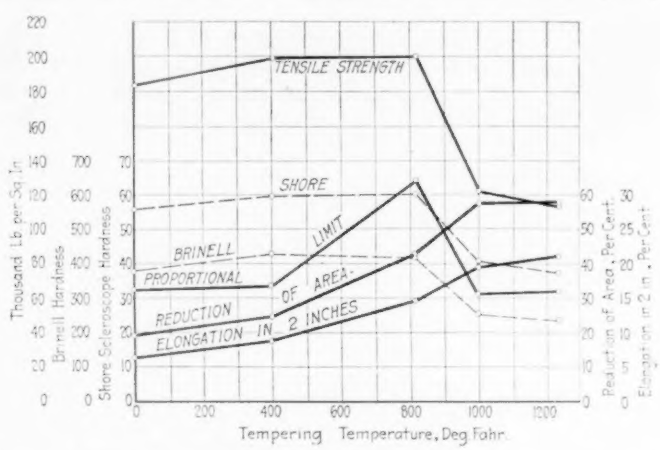


Fig. 4 Effect of Varying Tempering Temperature on the Physical Properties of a High-Chromium Steel, Oil-Quenched from 1750 Deg. Fahr.

So far, no relation between low impact values and resistance to fatigue or other ordinary tests has been found, but until proved otherwise heats showing temper brittleness should be specially treated or discarded. At least they should be questioned seriously when intended for important parts. This whole subject is now under investigation by a committee[1] appointed by the National Research Council.

[1] Committee on Physical Changes in Iron and Steel below the Thermal Critical Range, Dr. Z. Jeffries, Chairman.

TABLE 8 TEMPER BRITTLENESS OF CRANKSHAFT STEEL

Composition (per cent): C, 0.41; Mn, 0.50; Ni, 3.13; Cr, 0.82

Treatments:
1 Normalizing........1670 deg. fahr.—air-cooled
2 Hardening.........1510 deg. fahr. for 1 hour—oil quenched
3 Tempering........Heated 30 min. at 1100-1125 deg. fahr. and cooled as follows:
(a) oil............50 ft-lb. energy absorbed
(b) water.........48 ft-lb. energy absorbed
(c) still air........43 ft-lb. energy absorbed
(d) furnace (rate from 1050-775 deg. fahr. averages 2 deg. per min.) 8.7 ft-lb. energy absorbed

Carbon-Chromium Steels—Stainless Steel

Steels without nickel containing various percentages of chromium also find interesting applications in the automotive industry. For many years the use of chromium was restricted to high-carbon steels on account of difficulties in producing carbon-free ferrochrome. With improvements in production of ferroalloys some interesting steels have come into use.

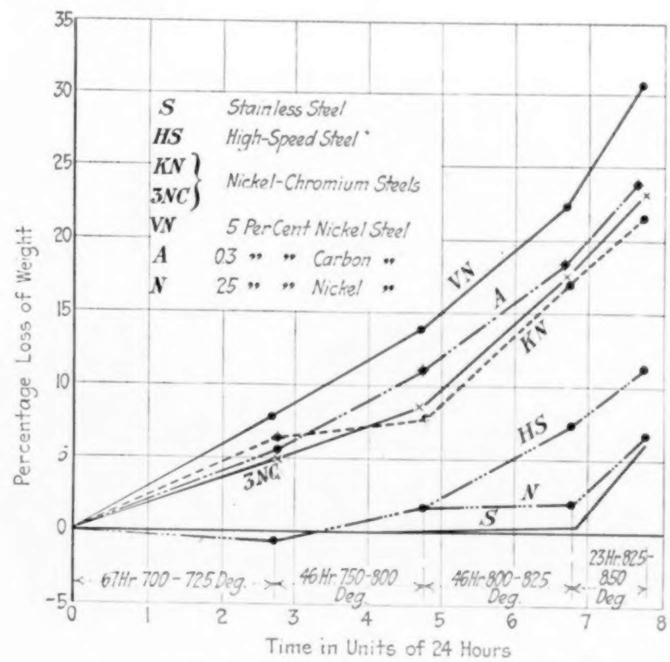


Fig. 5 Resistance to Oxidation of Various Steels

One of these is steel containing about 0.20 to 0.40 per cent carbon and 11 to 15 per cent chromium, produced under the name "stainless steel." Originally used for cutlery it has found successful application in valves for airplane and automobile engines where resistance to the action of hot gases and good strength and ductility are required. Figs. 3 and 4 show the effect of varying quenching and tempering temperatures on the tensile properties and hardness, while in Fig. 5 is shown the resistance to oxidation compared with common types of alloy and carbon steels.[1] The steel presents its maximum resistance to corrosion and oxidation only when properly hardened and finished (polished or ground). It is air-hardening in small sizes and may be quenched in oil, air, or water. Quenching is best carried out from about 1650 to 1750 deg. fahr. and for valves the steel is usually tempered at relatively high temperatures—about 1250 deg. fahr. Properties obtained after such treatment are shown in Fig. 4.

Cast High-Speed Steel Cutters

Before closing this discussion it will probably be of interest to touch upon another phase of the application of alloy steels in the automotive industry, namely, as cutting media. The follow-

[1] From tentative report of Iron and Steel Committee of the Society of Automotive Engineers, appearing in Jl. S. A. E., vol. 5, no. 3, Sept. 1919, pp. 262-263.

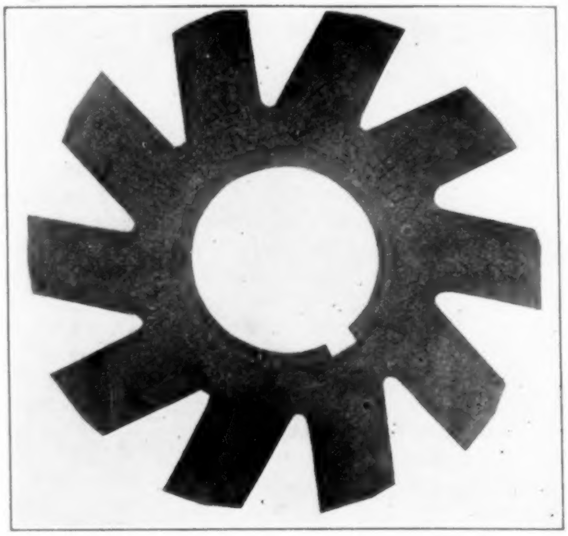


FIG. 6 CAST HIGH-SPEED STEEL MILLING CUTTER USED IN TEST; DIAMETER, 3.75 IN.

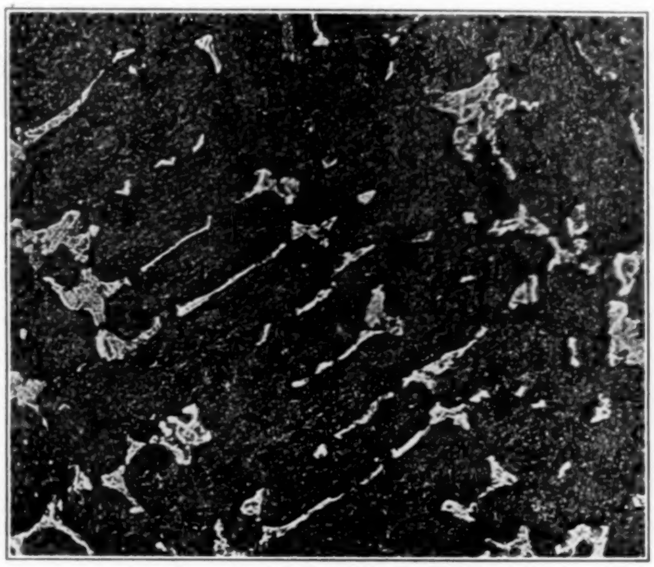


FIG. 7 STRUCTURE OF STEEL USED IN CUTTER OF FIG. 6 AS CAST, MAGNIFICATION, 500 DIAMETERS

FIG. 8 CAST HIGH-SPEED STEEL—HEAT-TREATED. MAGNIFICATION, 500 DIAMETERS

ing will be confined, however, to the results of tests made on some cast high-speed steel milling cutters, which in the past have generally been made from bars or forgings. This latter method when properly carried out has the advantage of decreasing machine work as well as of saving costly material, and produces cutters of equally high if not better efficiency than those machined from bars.

Fig. 6 shows one of the cast high-speed steel cutters used in the test about to be described and having the following analysis:

Carbon	0.85 per cent
Tungsten	19.40 per cent
Chromium	4.20 per cent
Vanadium	0.86 per cent
Manganese	0.05 per cent
Iron	74.60 per cent
Total	99.96 per cent

It will be noted that both carbon and tungsten are somewhat higher than proportions usually present in high-speed steel tools produced in the usual manner, and examination of the photograph shows a remarkably smooth surface, generally free from imperfections. The structure of this steel as cast is illustrated in Fig. 7, which shows the characteristic tree-like crystals of carbide, known as dendrites, imbedded in a matrix of softer material.

One cutter having a double set of teeth joined by a curved cutting edge was tried on rail steel at two different cutter speeds and depths of cut. One set of teeth burned immediately at a speed of 100 ft. per min. and 0.200 in. depth of cut, while the second set of teeth were worn so as to be useless after cutting 2 in. at a cutter speed of 45 ft. per min. and 0.100 in. depth of cut. Examination of the structure in Fig. 8 reveals the cause of this poor service. The treatment given has not brought the coarse carbide dendrites into solution, the cast structure persisting. Comparison with the structure of a properly hardened forged tool in Fig. 9 will make this clear.

Another cast cutter was annealed at 1650 deg. fahr. for one hour and cooled in the furnace, but did not machine well and was reheated at this temperature for five hours more and cooled in the furnace. After machining to standard milling-cutter shape it was heated to 1250 deg. fahr. in $3\frac{1}{4}$ hr., then raised to 2150 deg. fahr. in 10 min., and oil-quenched. After grinding it was subjected to test in comparison with a high-speed steel cutter of standard make, the results being given in Table 9.[1]

[1] Cutting test made by M. A. Grossman, formerly of the Bureau staff. Micrographs prepared in metallographic section of the Bureau.

(Continued on page 547)

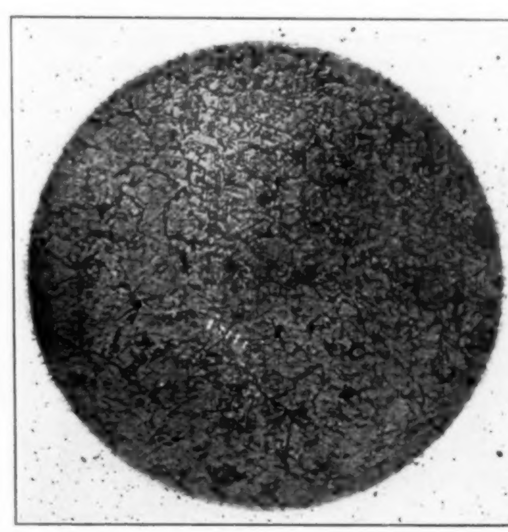


FIG. 9 FORGED HIGH-SPEED STEEL—HEAT-TREATED. MAGNIFICATION, 500 DIAMETERS

Some Commercial Heat Treatments for Alloy Steels

By A. H. MILLER,[1] PHILADELPHIA, PA.

The object of alloy-steel heat treatment, and indeed with a very few exceptions all heat treatment, is to produce a grain size as small as possible, with a degree of hardness suitable for the purpose intended. The three variables which must be controlled for a successful heat treatment are temperature, time, and rate of cooling, and together with these the influence of mass must not be neglected. The author of this paper deals with the heat treatment of alloy-steels used for structural purposes, especially of nickel and nickel-chrome steel. He describes a series of tests which were conducted to determine the effect of the various heat treatments on samples of the same chemical composition, and the varied results are illustrated by a series of photomicrographs which show the effect of different adjustments of the above-mentioned variables.

ALLOY steels, both for tool and structural purposes, have had an increasing application for a number of years. This paper is confined to a discussion of steels for structural purposes, and will further limit itself to their heat treatment. It will apply directly to the two alloy steels which are probably used to a greater extent than all others combined; namely, nickel and nickel-chrome steels. It is to be borne in mind, however, that the statements to be made in regard to these two alloys are almost equally applicable to all of the structural alloy steels, provided temperature changes are made which correspond to the changes in the critical temperature of other alloys.

In speaking of heat treatments, a fundamental thought must always be kept in mind: All fabricated steels are submitted to a heat treatment. The differences between steels known as heat-treated and others commonly spoken of as untreated is merely that the treated steels have supposedly received a preconceived, carefully-carried-out treatment, whereas the so-called untreated steels have received a variable and generally unknown treatment which is the result of casting, forging, and cooling at an unknown and variable rate from the casting or forging temperature.

The Time Element in Heat Treatment

In the heat treatment of alloy steels the three variables which must be controlled for a successful heat treatment are temperature, time, and rate of cooling. The influence of mass on these three variables must never be neglected; moreover, it must be borne in mind that an increase in mass may increase the treatment temperature, should increase the length of time held at temperature, and will inevitably alter the rate of cooling.

Too little attention is generally paid to the time element of the heat treatment, whereas it actually is of very great importance. The illustrations, Figs. 1-7, are a series of photomicrographs of a nickel-chrome steel of the following composition: carbon, 0.35-0.40 per cent; nickel, 3 per cent; and chromium, 0.75 per cent; and show the microstructure in a typical forged condition, and after annealing at a proper annealing heat for varying periods of time. It will be noted that this series gives the time held at the annealing temperature from zero (meaning that the piece was brought to temperature and the furnace was immediately shut down) to 10 hr. A study of the photomicrographs shows that the ferrite as contained in the cell outlines of the forged specimen was not dissolved and uniformly diffused until the piece had been held at the annealed temperature for ½ hr. Fig. 7 shows that there had been a slight growth of the austenite crystals between the time of completed uniform solution at ½ hr. and the end of the run, 10 hr.

This series also shows that a new cell system may grow in steel simultaneously with the breaking up of the previously existent system. The pieces, representative micrographs of which are shown, were all cut from the same bar, and were treated by placing them together in a furnace controlled by a thermocouple, withdrawing them one by one at the end of the specified time and plunging each immediately into a box of well-aerated lime.

The reason that a considerable length of time is required to produce a uniform structure is probably as follows: After the steel is raised to a temperature above the critical temperature, the iron is in the gamma form, in which iron carbide is soluble. There is, however, a certain length of time required for this solution, and, more than that, a certain added length of time is necessary to allow the solution to become homogeneous, just as, in dissolving a lump of sugar in water, a certain length of time is required to complete the solution, and a certain further length of time for the water to become uniformly sweet. Analogously, if the iron carbide be dissolved in the gamma iron and this solution does not have time to become homogeneous before it be recooled, the ferrite will naturally separate out on cooling at the point where the greatest concentration existed in the solution.

Procedure in Alloy-Steel Heat Treatment

The object of alloy-steel heat treament, and indeed, with a very few exceptions, all heat treatment, is to produce a grain size as small as possible, with a degree of hardness suitable for the purposes intended, by the simplest possible means. Thus the ill-controlled and generally very poorly forged structure must first be broken up and a fine uniform structure established. In steels which are sensitive to heat treatment, of which the nickel and nickel-chrome steels are excellent examples, this object is best achieved in several steps, each of which is designed to break up the structure resulting from the previous step and bring the material into a more nearly ideal condition.

If the forging conditions are bad, as is the case in most forging processes, especially that of drop forging, a treatment of numerous steps may be necessary. As an example of the most drastic the following is given:

1 Anneal from approximately 1450 deg. fahr.
2 Quench from 1600 deg. fahr.
3 Quench from 1400 deg. fahr.
4 Draw at 1250 deg fahr.
5 Quench from 1400 deg. fahr.
6 Draw at such a temperature as will give the desired hardness.

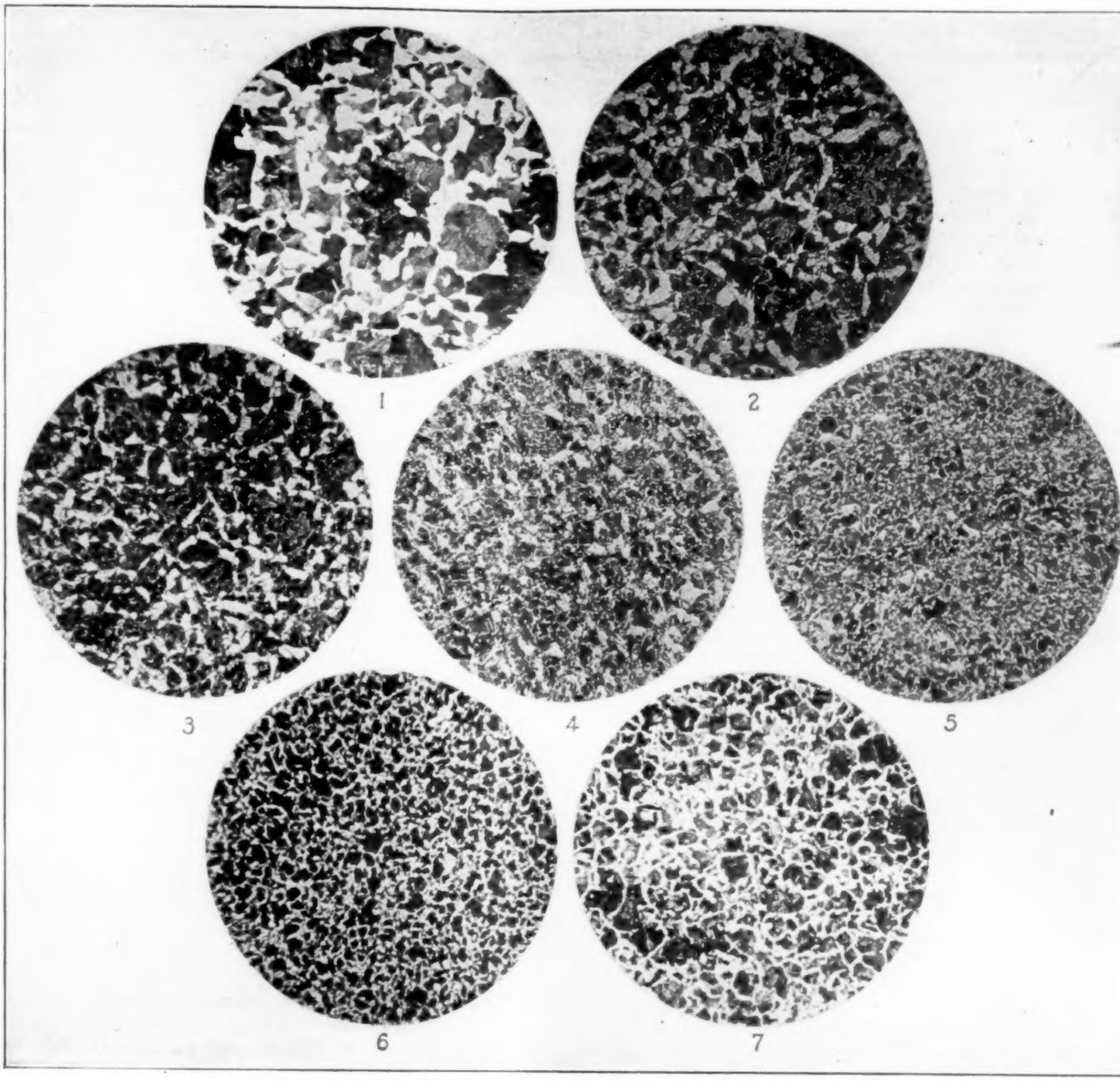
This heat treatment is not of unheard length, as it is quite conceivably necessary in many cases. As a matter of fact, in manufacturing pieces which will not subsequently be forged by the purchaser, steel companies very frequently give all of the preliminary steps of this treatment to their regular product. It must be well understood, however, that this number of steps is necessary only to guard against lack of uniformity, due to one piece out of a great number having possibly been subject to a poor forging heat. If the forging temperature can be accurately regulated, however, many of the steps in this treatment can be eliminated.

In much commercial work, with good forging practice, a simple anneal at 1450 deg. fahr., followed by a quench just above the critical temperature and a draw, will put the steel in excellent preliminary condition, at which point the steel can be machined to its final shape. If conditions are such that the steel must be extraordinarily hard (as, for instance, in automobile gears), a final quench with a draw at about 400 to 600 deg. fahr. is then given.

It must be borne in mind when laying out treatments that the time at which the steel is held at temperature during any treatment, whether it be an anneal or a quench, is of quite as great

[1] Research Department, Midvale Steel and Ordnance Co.

Presented at a meeting of the Washington Section of The American Society of Mechanical Engineers, March 31, 1920.



FIGS. 1 TO 7 EFFECT OF TIME AT NORMALIZING HEAT (1450 DEG. FAHR.) FOLLOWED BY SLOW COOLING

Fig. 1 As forged. Fig. 2 Not held, cooled in lime. Fig. 3 Held 5 min. Fig. 4 Held 10 min. Fig. 5 Held 15 min. Fig. 6 Held 30 min. Fig. 7 Held 10 hr. x 80.

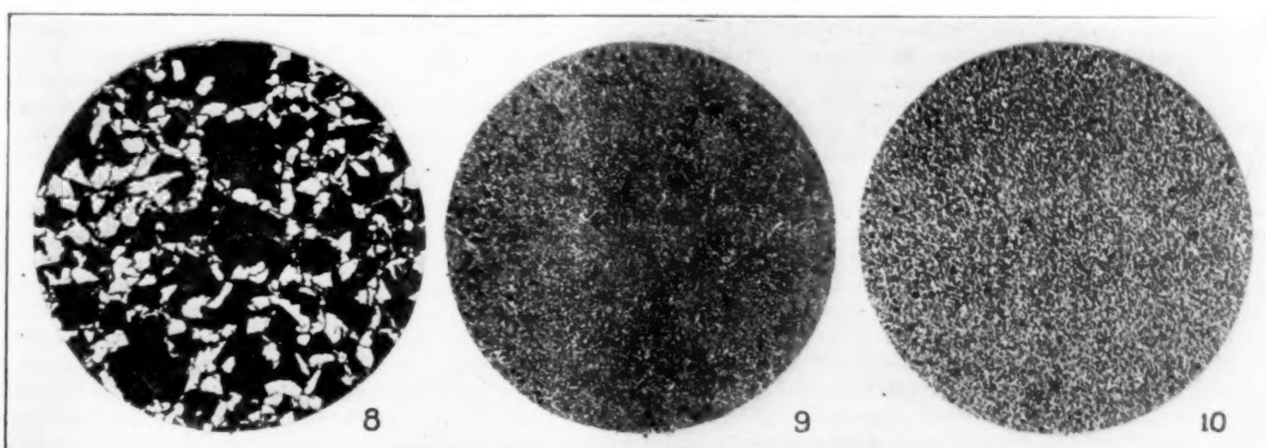


FIG. 8

Heated to 1,400 deg. fahr.
Not held, quenched in oil.
Reheated to 1,150 deg. fahr
Held 30 min.
Cooled slowly. x 100.

FIG. 9

Heated to 1,400 deg. fahr.
Held 30 min.
Quenched in oil. x 100.

FIG. 10

Heated to 1,450 deg. fahr. for 30 min., cooled slowly.
Heated to 1,600 deg. fahr. for 30 min., cooled slowly.
Heated to 1,400 deg. fahr. for 30 min., cooled slowly
Heated to 1,150 deg. fahr. for 30 min., cooled slowly.
x100.

importance as the temperature. This is illustrated by photomicrographs, Figs. 8-10, of two pieces cut from the same bar as those previously shown, both of which were placed in the furnace together. One of these pieces was drawn from the furnace and quenched immediately it had reached the quenching temperature (in this case 1400 deg. fahr.). The other was allowed to remain in the furnace for $\frac{1}{2}$ hr. and was then quenched. It will be seen that the ferrite areas in the first case had been slightly or incompletely broken up, whereas in the second case they were very completely dissolved.

These photomicrographs differ from a corresponding one in the first series of annealed samples in that there is shown no new grain growth within the old partially broken-up system. This, of course, is due to the fact that in the second case the time element necessary for the separation of the ferrite during cooling was not sufficient.

Results Obtainable in Heat-Treating Alloy Steels

From results obtained in the careful heat treatment of nickel-chrome steels, a series of curves, Fig. 11, has been prepared which show the physical properties of a nickel-chrome steel resulting from proper preliminary treatment and varying drawing temperatures.

The type composition only is given in this figure, because it is

C	Mn	P	S	Si	Ni	Cr	V
A0					3.00	.75	

Critical points / data	Operation	Size treated	Temperature	Time at heat	How cooled	Remarks
Ac1 1325° Ac2 ____ Ac3 1360°	1 Quenched	1" round	1600°	½ hour	Oil	
Ar1 ____ Ar2 ____ Ar3 ____	2 Quenched	1" round	1400°	½ hour	Oil	
Curves average of 20 tests	3 Drawn	1" round	1250°	½ hour	Lime	
Submitted by Midvale S. Co. Nicetown	4 Machined	to .505" round				
Test piece 2" × .505" diam.	5 Quenched	.505 round	1400°	½ hour	Oil	
Date August, 1914	Drawn or annealed as indicated on curve			1 hour	Air	

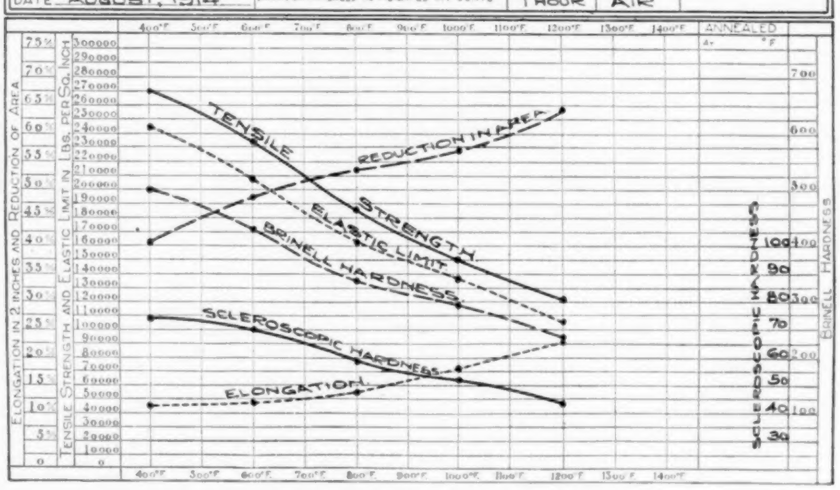


FIG. 11 PHYSICAL PROPERTIES OF A NICKEL-CHROMIUM STEEL RESULTING FROM PROPER PRELIMINARY TREATMENT AND VARYING DRAWING TEMPERATURES

a mean of the results of about twenty bars from several heats of slightly varying compositions. The nickel steels of the same approximate carbon content give results which are somewhat inferior to this nickel-chrome curve, whereas the results of another type of nickel-chrome steel, of $3\frac{1}{2}$ per cent nickel and $1\frac{1}{2}$ per cent chromium, would be slightly superior.

Starting from the extended heat treatment just described, the development of the cheapest and simplest treatment which will give good results is a matter of intelligently eliminating or altering steps of the ideal heat treatment as conditions permit. For instance, in a certain case where important drop forgings were manufactured from the grade of nickel-chrome steel shown on the curve, the actual treatment to which pieces were subjected is as follows: The pieces were forged under a drop hammer, and were dipped immediately afterward into a tank of oil which was maintained close to the forge. The pieces were kept in this oil for about four minutes, removed at a temperature between 700 to 900 deg. fahr., and were buried in ashes as a precaution against cracking. Then the pieces were subjected to a single quench at 1400 deg. fahr. and were drawn at 1200 deg. fahr., in which condition they were machined and received no further treatment. The uniformly excellent results obtained (each of the pieces was separately tested) showed that this very simple treatment had been entirely effective. A little thought will show that the reason for this was that the drop forging was not excessively high, and that the growth of large-cell outline was prevented by the quench after forging was completed. The single quench and draw were sufficient to completely refine the steel from the fair condition which was thus produced.

There is this to be observed in all cases of quenching of alloy or indeed any other steels: Following the quench, the piece quenched is in a condition of great strain and is liable to crack. This liability to crack persists until the piece has been drawn, and it is therefore wise to draw the piece as soon as possible after the quenching.

In cases where a drastic quench is advisable it is better to remove the piece from the quenching medium before it becomes entirely cold. By this procedure the great proportion of the condemnations due to cracking are avoided.

Fiber Fracture a Criterion of Proper Treatment

One of the significant effects of a correct heat treatment on alloy steels, which is indeed a criterion as to the efficiency of the treatment, is the production of a peculiar type of fracture in a broken piece, known as "fiber." This fiber fracture is absolutely distinctive, and cannot be mistaken by one who is even slightly skilled in inspection. It is produced in all of the well-melted, shock-resisting alloy steels by proper heat treatments, and is so closely related to impact test values that failing impact tests can almost invariably be selected from broken impact test bars by the absence of this type of fracture. The ease of producing fiber by heat treatment is a criterion of the value of an alloy for shock-resisting properties. So important is the presence of this feature that armor plate, which must withstand shock test of the more severe character, is never knowingly shipped without it.

In its report covering its activities for the year 1919, The National Physical Laboratory (England) reviews its accomplishments in many fields of science, among them being its work in metallurgy. The most important work in the Metallurgy Department of the laboratory was in connection with the production of light alloys, especially for aircraft and aeroplane engines. Alloys were developed to meet special requirements for castings in general, and for parts such as pistons working at high temperatures; wrought alloys were produced for use in the construction of rigid airships, aeroplane spars, etc.; and the rolling of light alloys into thin sheets to serve as a substitute for fabric in covering aeroplane wings was successfully accomplished. Special investigations were made with the object of providing substitutes for alloys for munitions when difficulties of supply arose. Among these was a substitute for the use of antimony in hardening lead for shrapnel bullets. Another case in which a substitute was required was the aluminum tip forming part of the standard small-arms bullet at the beginning of the war. The possibility of replacing the aluminum tips by bodies of precisely similar size, shape, and weight was thoroughly demonstrated, with the collaboration of a pottery in the Manchester district, where the difficulty of preparing small pottery bodies with the necessary accuracy of shape and dimensions was successfully overcome. Investigations were made on steel for torpedo air vessels and turbine gearing, and methods of hardening and case-hardening war material were improved.

The St. Lawrence River Project

An International Project Which Promises Unlimited Benefits in Solving the Transportation Problem of Central North America as Well as the Fuel and Power Crisis of the Eastern Seaboard

By HORACE C. GARDNER,[1] CHICAGO, ILL.

For centuries the rapids of the St. Lawrence have been regarded as a drawback to the development of the surrounding country, and in the sense that the people of a century ago comprehended the matter they are still a disadvantage. But with the existing demands for power and inland transportation systems already breaking down under the stress of traffic, the river and its rapids should be looked upon as a resource and one of nature's best gifts, for they furnish the solution to both power and transportation problems. It is to this proposition that the author of the following paper has addressed himself. If developed, the improved St. Lawrence, together with the Great Lakes, would constitute, the author states, a waterway from the heart of North America direct to the continent of Europe. And as a result an ocean steamer could be loaded at a Great Lakes port and not discharge its cargo until it reached a European port. This, of course, would relieve the congestion which now takes place on the railroads every year during the season when the crops of the West and Middle West are shipped to the seaboard. It would also materially lessen the car shortage which occurs during that period, and moreover it would lessen the expense of shipping. The problem, the author states, is not a new one. It is over a hundred years old, and during the past seventy-five years the Canadian Government has been making improvements, most of which, however, are not large enough for the present demands. At the present time the Great Lakes-St. Lawrence Tidewater Association is endeavoring to encourage coöperation between the United States and Canada in the development of the St. Lawrence both for navigation and power. The International Joint Commission, which consists of three representatives of the United States Government and three representatives of the Canadian Government, are also holding hearings at various places in both countries to learn the sentiment of the people. The paper is an interesting discussion of an important problem which is bound to receive considerable attention in the immediate future.

In 1534 Francis I, King of France, commissioned that most famous French navigator of the time, Jacques Cartier, to attempt the discovery of the much-sought northwest passage to India. Accordingly in the spring of that year Cartier sailed from St. Malo and spent the summer in and about the St. Lawrence gulf, during which time he circumnavigated Anticosti Island. He actually entered the mouth of the St. Lawrence River, but he was not sure as to whether it was a river or an arm of the sea. In 1536 Cartier made another expedition and explored the St. Lawrence for 550 miles, or as far as the present site of the city of Montreal. The encouraging results of these expeditions brought about others, and eventually the five fresh-water inland seas that have come to be known as the Great Lakes were disclosed to the world, which, together with the St. Lawrence, constitute one of the finest, and in many respects one of the most remarkable, fresh-water basins and drainage systems on the globe.

The entire distance from the headwaters of the St. Louis River, in Minnesota, which flows into Lake Superior, to the mouth of the St. Lawrence River, is 2100 miles. The lakes themselves, constituting enormous reservoirs, cause the great river to have the most even flow of any of the earth's large streams. The variations between mean flow and maximum and minimum is but 25 per cent of the mean in contrast with thirty times the minimum at the mouth of the Ohio, and practically the same extremes in the Mississippi at Keokuk.

But the great disadvantage of the river is its rapids, the greatest of which is the Lachine, which ends at Montreal. The total fall between the outlet of Lake Ontario and mean tide at St. Lawrence is 221 ft. For centuries these rapids have been regarded as an enormous disadvantage, but with the present need for power and modern methods of development the people of both the United States and Canada are sure to reach within a decade or two a condition of thankfulness that the rapids exist.

It will perhaps be interesting to speculate as to what would have been the order of development of population and industry on the North American continent had the St. Lawrence been an ordinary stream without the great rapids and had the Great Lakes been connected to this outlet by intermediate channels with only the normal fall of the usual river. The St. Lawrence proper was explored for its full length in 1536, and it will be recalled that settlements were made on the Atlantic Coast as follows: Jamestown, Virginia, in 1607; New Amsterdam (Manhattan Island) in 1615; and Plymouth, Mass., in 1620. It would therefore seem evident that had it been possible to conduct water transportation by the vessel of that day from the Great Lakes basin directly to Europe, actual colonization would have been under way on both shores of Lake Erie and Lake Ontario while the English were establishing themselves on the Atlantic Coast and the Dutch in eastern New York. The impetus then would have been in the Great Lakes basin; and, with the superior fertility of these lands in mind, it seems probable that populous centers would have been established on the shores of the Great Lakes, with settlements and developments extending westward, and with the less fertile marginal lands along the Atlantic Coast in a much more backward state. But nature provided otherwise, and the rapids of the St. Lawrence proved so much of a barrier to commerce that it took a century for the advance of civilization to reach Detroit and another century to reach Ft. Dearborn; and it was not until recently that the people awakened to the supreme necessity of providing adequate facilities so that ocean-going ships may pass up the St. Lawrence and navigate these fresh-water seas in the heart of the continent.

The territory included within the heavy lines on the map of the United States, shown in Fig. 1, is economically nearer to the ports of the St. Lawrence and Great Lakes than to any seaport east, south or west, either in actual miles or because of mountain ranges to be crossed. This territory is correctly called the heart of our country. It embraces something more than a third of our continental area, with more than a third of the population and more than a third of the wealth. All who know the United States are aware of the fact that in this area lies potentially much more than one-third, and probably much more than one-half, our productive capacity. According to the latest figures available its present productivity may be stated as follows, in terms of percentage of the total:

Corn	65	Apples	21
Wheat	74	Beet sugar	53
Flax, practically	100	Wool	47
Cattle, over	50	Coal mined	36
Hogs	57	Coal reserves	72
Horses	60	Copper	39
Butter	54	Lead	46
Eggs	54	Iron ore	85
Cheese	57	Zinc	74

On the map of Fig. 1 it will be noted that various centers are indicated by numbered circles. These are the centers of production of various products, comprising practically all of the fundamental necessities of life.

With one exception—the center of population—the locations are the crossings of median lines. There are two methods of determining such centers. One is to calculate and determine a point at which, if all of the given product were assembled and piled in one pile, the least possible transportation would be necessary. The

[1] Gardner and Lindberg. Mem. Am. Soc. M. E.

Abstract of a paper presented before the Chicago Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, June 8, 1920.

center of population as shown on the map was so determined by the Census Bureau. The other method, and the one used with respect to all of the centers except population, is to determine a north and south line, east and west of which half of a given product is produced; then determine an east and west line, north and south of which half is produced. It is at the crossing of these median lines that the center is located. In determining the centers used in this paper, other than the center of population, the latter method was employed.

To theorize further on the two methods, the determination of the crossing of median lines gives quite as useful and satisfactory results as the first method, but it would not necessarily do so with respect to everything, as, for example, citrus fruits. These are grown in Southern California, to a small extent in Arizona, and in Florida. The actual center would probably lie in the eastern part of Southern California. If Florida produced approximately the same quantity as California, a north and south line bisecting the total production might lie almost anywhere between California and Florida, and would certainly come in a territory of no production. Fortunately, most of our fundamental staples are produced over large areas, and the method of determining the crossing of median lines is as accurate and satisfactory as any that can be devised. Moreover, in considering the significance of the location of such centers, the normal direction of freight movement, which is always from the region of greatest production toward the region of less or no production, must be kept in mind. Grain, foodstuffs and feed move always toward the east, while manufactured products, for the most part, move toward the west.

The centers as shown on the map have been determined by the use of the latest figures available. The center of population was determined according to the census of 1910. Many of the most important figures are founded on figures of the Census Bureau bearing the date of 1914, but these centers do not shift rapidly.

The Present Freight Situation

And yet with all this potential and actual wealth both the United States and Canada have suffered, for business has been hampered by the lack of transportation. There are many reasons for this condition, but the fundamental one is due to the fact that such an enormous part of the total production must travel long distances by rail and the railways are congested progressively as one moves eastward. The greatest transportation demand comes every year at the crop-moving season. Taking the experience of past years, it is found that the distribution of car supply is such that some sections of the country have too many and others too few cars to handle the business. As a rule, cars are well distributed in the spring, but when the crop-moving season begins there is always an abnormal movement of the car supply toward the seaboard. At the height of this season the distribution is so abnormal that the supply of cars east of the Alleghany Mountains is about 120 per cent and in the central part of the country about 80 per cent of the normal supply. This condition prevails for several months. It occurs, of course, because of the large amount of tonnage which the railroads must carry during the fall and early winter. There is a very natural disposition upon the part of the railroad lines to hold empty cars for westbound loading, hoping that they may be relieved of the necessity of moving cars without load in great numbers and over long distances. To some extent this is justified, because the demand for merchandise always increases after the crops are moved and the farmers have the increased buying power that comes therefrom. To some extent, no doubt, the railways delay empty-car movements longer than they should to postpone this dead expense. They are particularly prone to do so when there is a shortage of motive power and of man power, also a shortage of fuel, all three of which conditions have prevailed within the past six months.

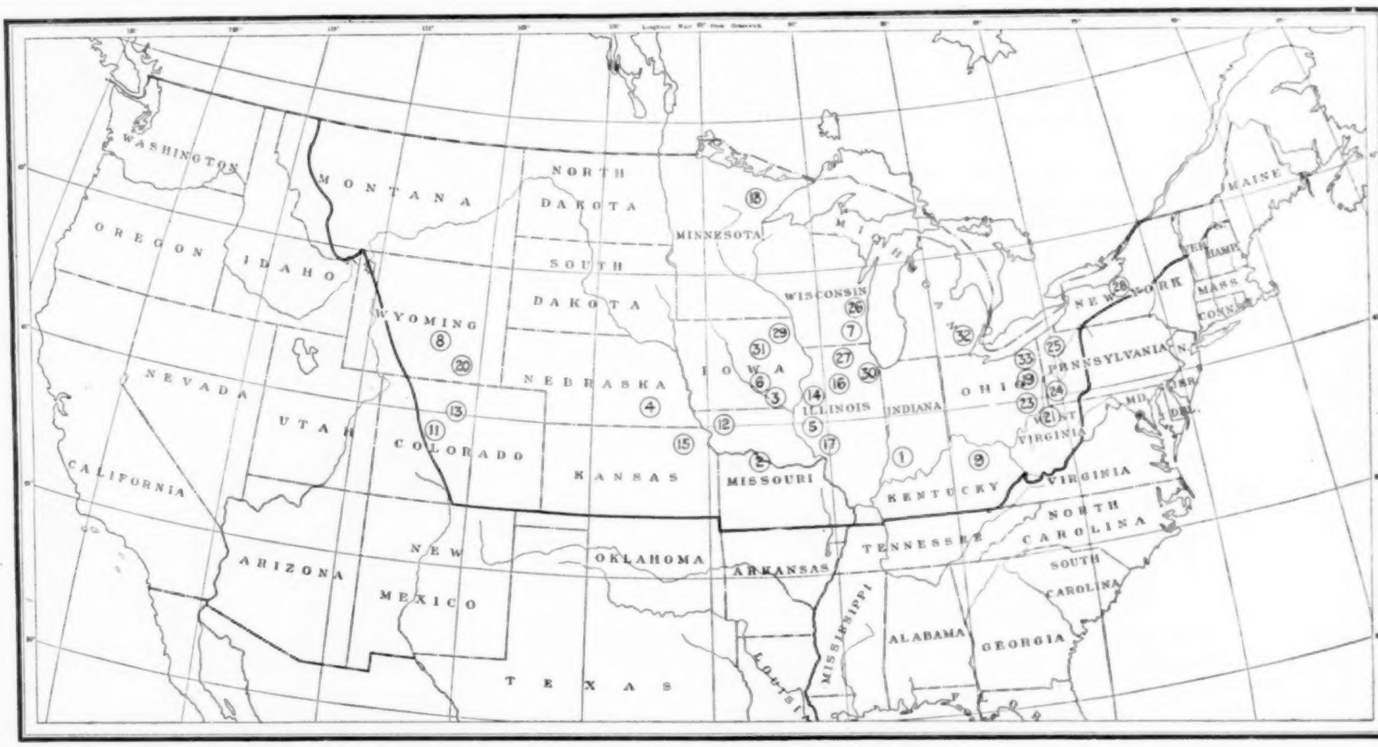


Fig. 1 Centers of Productivity in United States

During the latter part of 1919 and up to the present time, instead of working toward a normal car distribution as might be expected during that season of the year, conditions have become increasingly worse, not only because of the three conditions just named but also on account of the shortage of vessel room for export cargoes and of local strikes among the railway switchmen and dock laborers. In fact, vessels have lain at anchor in New York Harbor for weeks waiting for a place to berth. The whole situation has become almost intolerable and in many cases shippers have been put to great and unexpected expense. Three or four cases of excessive charges on export consignments shipped through the port of New York within the past few months are as follows:

Case 1—6 barrels, weight 521 lb.:	
Freight to New York	$4.94
Cartage to warehouse	4.50
Cartage to steamer	4.50
Overtime for delay of truck	7.20
Case 2—8 crates, weight 96 lb.:	
Freight to New York	$0.96
Cartage to warehouse	6.00
Cartage to steamer	6.00
Case 3—156 packages toys:	
Freight to New York	$22.56
Freight to warehouse	78.00
Cartage to steamer	14.25

Such conditions are necessarily ruinous to export trade because shippers cannot possibly satisfy their customers, nor can they afford to take the risk of making prices that would under ordinary conditions afford them a reasonable profit. No doubt a considerable part of our high cost of living comes from exactly such conditions. At our various ports and at many other interior points our domestic shipments have been delayed as well as subjected to many unusual expenses.

What is the remedy for this intolerable state of affairs? The answer is short—better transportation. There are, however, many ramifications of the problem. First, our railways must be rehabilitated, provided with an ample number of cars and adequate motive power, and must build up their personnel to take much better care of business. Fundamentally, however, it is wrong to impose upon the railways the enormous peak load of tonnage that comes every year during the crop-moving season, requiring them either to build up their freight-carrying capacity equal to the peak and consequently to have much of their rolling stock and power idle for several months in the year, or to repeat just what is being experienced at the present time; that is, to allow empty cars to pile up in the eastern zone and suffer the consequent shortage in the Central West.

A study of figures showing our exportations of grain and heavy freight shows that if we could load vessels at the ports of the Great Lakes and sail them direct to European ports, practically all of the excessive peak load could be absorbed and incidentally a tremendous car-mileage could be avoided. For example, wheat, which constitutes the greatest tonnage item of all our exports, comes principally from the Dakotas, Minnesota and Kansas. Think of the car-mileage involved in transporting this wheat to the Atlantic seaboard that could be saved if the vessels were loaded at the convenient ports on Lake Superior, Lake Michigan, and at Detroit and Toledo. Furthermore any railway system upon which tonnage of this class originates that could deliver directly to docks without leaving its own rails, could have much better control of disposition of empty cars; they could be rushed west for reloading not only without delay but without any of the red tape and trouble incident to business that must move over two or more railway systems.

The real remedy, then, for our annual freight blockade would seem to be to open the Great Lakes so that ocean-going vessels may freely enter and make use of the various ports, at many of which our railway systems already center. This being an acknowledged fact, it is, indeed, rather puzzling to know why we have suffered for so many years so greatly without taking real steps to remedy the difficulty.

Past Improvements and Progress

In applying our remedy such improvements of the St. Lawrence River and of the canal across the Niagara peninsula must be made that vessels of ocean-going type and large size can be admitted. The subject is almost a century old; in fact, in an academic way it was thought out and discussed much more than a century ago, and three-quarters of a century ago a series of canals were built around the various rapids of the St. Lawrence River and across the Niagara peninsula. These, while adequate for their time, were soon outgrown. They were improved somewhat so that vessels drawing up to 14 ft. of water might come and go. However, with the rapid increase in the size of ships these canals soon proved too small and have constantly hampered commerce. Something over twenty years ago the subject became quite active and the Canadian Government undertook surveys and estimates as to the practicability and cost of improving the Ottawa River and the building of a canal across the divide to the French River and down that stream to Georgian Bay. Even then their ideas as to size were such as would not now receive serious consideration. These surveys and estimates showed, however, that canals with the depth and lock capacity for vessels of 20 ft. draft would cost practically $100,000,000. There was at that time in Canada a considerable sentiment in favor of building a canal entirely through Canadian territory. About the same time consideration was given in this country to the idea of building a canal from Albany to Lake Ontario. Fundamentally the plan was, of course, to meet the proposed all-Canadian canal with an all-American canal. Studies and estimates were made in detail. One of the propositions considered was for a canal with a depth of 30 ft. The estimate at that time gave the cost as about $200,000,000. Nothing was done, however, and we were soon in the midst of the Spanish-American War, following which the Panama Canal attracted the attention and energy of the country.

About two years before the European War began, Canada undertook on her own account the construction of a new Welland Canal across the Niagara peninsula; the depth through the earth sections to be 25 ft. and the miter sills of the locks 30 ft. The expected cost was $50,000,000 and the work was well under way when, in the summer of 1914, Canada found herself at war. The work was courageously continued for about one year, when for financial reasons and lack of man power it was stopped. Within a year after the armistice Canada resumed work, and it is expected this canal will be finished within three years. It will be adequate for the typical ocean freighter of today, in fact, for all of the commercial fleets of the world with the exception of a very few large ships, which are principally used on the North Atlantic.

What about the St. Lawrence Rapids? How can they be avoided or what may be done to enable vessels to come up and use the new Welland Canal? About a dozen years ago, Gen. W. H. Bixby, then Chief of Engineers of the United States Army, pointed out in an address that a full investigation would probably show that the St. Lawrence might best be improved by building a series of great dams, drowning out the rapids and converting them into lakes, putting in locks so as to pass vessels of any size desired. This suggestion, which by the way General Bixby does not claim to have originated, was of course not based upon definite surveys and full engineering consideration, but it seems to be the general opinion that, upon full study, this method will be found the best. One of its great advantages is that it would incidentally develop a large amount of power.

Recent Progress

In the very early days of 1914 a committee representing commercial and other bodies in the Central West visited Washington and took up with the Department of State the question of uniting with Canada in the making of adequate improvements in the St. Lawrence so that both countries might have the use of channels and facilities suitable for ocean-going ships; also the development of the incidental power. The Department of State officially brought up the question with the Canadian Government and it was pending when the war came on and then of course nothing was done. A little over a year ago the subject was again taken up and an organization known as Great Lakes-St. Lawrence Tidewater Association was effected, the purpose being to create in this country a sentiment in favor of uniting with Canada for the improvement of the St. Lawrence both for navigation and power. This association has working headquarters in Duluth and it became active at once. Generally, a most sympathetic feeling was experienced and Congress was appealed to and very promptly passed a joint resolution referring to the International Joint Commission the problem of (*a*) an investigation as to the need for the improvements; (*b*) the best method; (*c*) the probable cost, and (*d*) the proper and equitable division of the cost between our country and Canada.

The International Joint Commission is composed of three members from the United States and three from Canada. It is a standing Commission that has been in existence for eleven years. It was created by virtue of a treaty between the two countries, and has jurisdiction of all boundary waters and problems in connection therewith.

Immediately after our Congress passed the joint resolution the Canadian Government, by order in Council, took the same action. Following this each government appointed a conferee to consider the exact instructions to be issued and to lay down for the International Joint Commission the exact scope of the work to be done. These conferees agreed promptly on the series of problems and questions. The two governments also each appointed an engineer charged with the duty of deciding upon the engineering questions; that is, the best method for making the improvement and the probable cost. The engineer for the United States is Colonel Wootten, an army engineer stationed at Detroit. The engineer representing the Canadian Government is Mr. W. A. Bowden. These engineers are actively at work. The International Joint Commission is now engaged in a series of hearings as to the need for the improvement; they have had meetings and presentations have been made by commercial bodies and others at various points in Canada and in the states of North and South Dakota, Montana, Idaho, Wyoming, Colorado, Nebraska, Iowa, Minnesota, Wisconsin, Michigan, Ohio and New York—additional hearings to follow in October. It is hoped that the Commission will reach an agreement and file its report with the two governments next December.

Advantages of St. Lawrence River Route

To the American mind, of course, very naturally comes the question, Why the St. Lawrence? Why not an all-American route up the Hudson and into Lake Ontario? There are, however, several very good reasons for favoring the St. Lawrence. In the first place, nature shaped the course of the St. Lawrence so that it runs from the heart of the North American continent directly toward the principal ports of Europe. This fact, however, is somewhat difficult to realize from the ordinary map.

Fig. 2 shows, as well as can be shown on a flat surface, the relation of not only of the St. Lawrence River and its outlet but of the entire Atlantic coast of the United States and the Atlantic coast of Europe. The following comparisons of distance should be of interest: Rochester is nearer to Liverpool than New York; Buffalo is but a few miles farther; Toledo is nearer Glasgow, Belfast and all the Scandinavian and Baltic ports than New York; Detroit is but a few miles farther. From all our ports on Lakes Ontario and Erie it is 250 miles farther to Liverpool, London and the northern French ports and all North Sea ports via New York than via the St. Lawrence; to Glasgow, Belfast, Scandinavian and Baltic ports this differential is 500 miles. To the Mediterranean ports, however, the handicap via the St. Lawrence is but slight and not worth mentioning. It is readily seen, therefore, that distance is in favor of the St. Lawrence route.

Another reason is that there are but 45 miles of rapids, and if these be drowned out by the building of the dams, there would be a minimum of restricted channel.

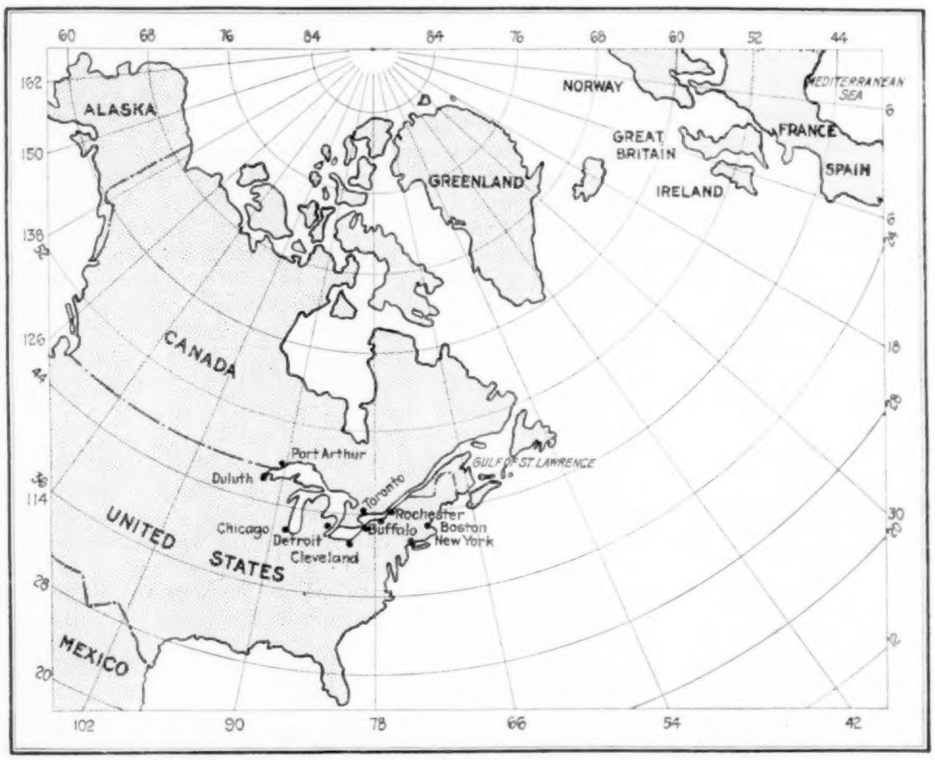


Fig. 2 Relation of Atlantic Coasts of United States and Europe

Hydroelectric Resources

Another tremendous benefit to be derived is that of hydroelectric development. The normal mean flow of the St. Lawrence River at its outlet from Lake Ontario is 240,000 sec-ft. There are a number of affluents but they are all of minor consequence, except the Ottawa, which enters the St. Lawrence just above Montreal, and hence are not to be considered as amounting to much so far as the power development is concerned. There is between the head of the rapids near Ogdensburg, N. Y., and the foot of the lowest rapid just at the city of Montreal, a total fall, as before stated, of 221 ft. This is divided into several rapids, and in the river proper above Montreal there are two lakes: Lake St. Francis, about 30 miles long, and Lake St. Louis, about 16 miles. Of course these lakes would not be interfered with. Some channeling has already been done in them, but more is necessary. The levels will probably be raised somewhat by the series of dams already spoken of, and the pools that would be caused by them, together with these two lakes, as well as the whole body of Lake Ontario, would give a reservoir capacity that would be ample, so that the river flow might be almost absolutely controlled and the power production timed to meet the demand. In fact, there is now under consideration by the two governments the question of controlling not only the flow of the St. Lawrence but of the Niagara River as well, the purpose being to compensate for the diversion of water through the Chicago Drainage Channel. The Sanitary District Trustees have offered to meet the cost, which is comparatively small. This question of control of the flow of the St. Lawrence will no doubt be merged with the improvement of the river for navigation and power. Deducting from the 240,000 sec-ft., say, 10,000 sec-ft. for diversion through the Chicago Drainage Channel, and reckoning on the remaining 230,000 sec-ft. at full head, the power development on the 100 per cent basis would amount to 5,750,000 hp. If 70 per cent can be realized, the development will amount to over 4,000,000 hp. Offhand, this would seem to be practicable.

The first 113 miles of the river from its outlet from Lake Ontario are international, that is, they constitute the boundary between the two countries. The fall in this section, which is confined to about 45 miles, is 92 ft. and the power possibilities, on the same basis, would be practically 1,660,000 hp. Normally half of this would go to Canada and half to the United States.

(*Continued on page 527*)

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Recent Utilization of Water Power

In the years 1890-1898 a power station was erected at Chevres, near Geneva. It consisted of 15 Jonval turbines of the multiple-runner type, each having an output of 1200 hp. under a maximum head of 26.5 ft. and at a speed of first 80 r.p.m. and then 120 r.p.m. In its day, which was not so long ago, this plant was representative of the highest stage of hydraulic engineering as it existed. If this plant were built today and equipped with high-capacity Francis turbines, a *single*-runner turbine at 120 r.p.m. would give an output per unit of 2500 hp., or, conversely, with an output of 1200 b.hp. the maximum speed would be approximately 175 r.p.m., which would mean a very material saving in the cost of the electrical-generator equipment. With each unit consisting of a double Francis turbine, a maximum output of 5000 b.hp. would be secured at a speed of 120 r.p.m., or with the original output of 1000 b.hp. a speed of 290 r.p.m. would be obtained.

To present the recent advances and present state of water-turbine development was the purpose of the paper recently presented before the Institute of Mechanical Engineers (Great Britain), by Eric M. Bergstrom, from which the above facts are taken.

Under the heading of Francis turbines Mr. Bergstrom calls attention to the early development of standard turbines which could be sold at an exceedingly low cost. This was followed by an increase in size of units specially designed for the conditions of installation which gave considerably greater economies than could be realized from standard machines. Following this development came the recognition of the value of "specific speed," which many leading manufacturers now use as the basis for the manufacture of standard runners, a series of runners corresponding to a certain specific speed being selected as standards to meet the conditions most frequently met with.

The important factor in connection with modern turbine practice is that exhaustive tests have been made giving a complete knowledge of the efficiency and other characteristics of each standard wheel made, so that knowledge of its behavior under varying conditions will enable a runner to be selected which will meet most efficiently a given set of requirements. The standardization of the modern turbine has been developed from these improved methods of systematic tests which provide definite knowledge of the chief characteristics of the turbine. The early American standardization practice was empirical in nature and did not encourage further developments.

It is a general practice for European turbine manufacturers to install testing plants within their own works. This enables them to accurately analyze not only standard runners, but any new special designs. The importance of tests of research work has best been shown by the evolution of the Francis runner, the development of which has been possible by exhaustive trials and intelligent applications of the results obtained.

The development of the high-capacity runner has enabled designers to use a higher value of specific speed during the last ten years. Where the limit of specific speed was approximately 75 (330 metric system) in 1909, today turbines have been installed with a specific speed of approximately 95 with good efficiencies resulting. It is now possible to obtain runners of specific speed of 100, together with even a higher maximum efficiency than secured previously with a specific speed of lower value and with only small sacrifice in efficiency at part gate.

A design of runner recently constructed by the Escher Wyss and Co. gave good results at speeds corresponding to a specific

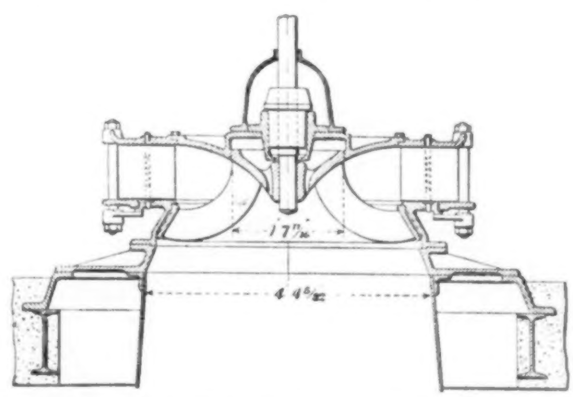


Fig. 1 New Type of Turbine, Built by Escher Wyss & Co.

speed of from 85 to 112. The main feature of this new turbine, shown in Fig. 1, is the large space between the guide vanes and the entrance edge of the runner.

Two examples of notably high efficiencies are given: the American installation at the Appalachian Power Co. with a 6000-hp. single open vertical unit operating under a 49-ft. head at 116 r.p.m., specific speed 69.5, with an overall efficiency of 93.7 per cent; the Forsse Hydroelectric Plant, Sweden, with a 3750-hp., double enclosed horizontal unit, operating under a 57-ft. head at 250 r.p.m., specific speed 80, giving a maximum overall efficiency of 94 per cent. Other efficiencies ranging from 87 per cent up are given of plants installed in Norway, Switzerland, Canada, and the United States.

It follows logically that these most notable achievements in maximum efficiencies are the results of the more careful and correct runner design referred to before. Improvements in the design of casing, guide apparatus, suction casings and suction tube are based on a better understanding of the conditions of flow in various parts of the turbine, thus eliminating as far as possible impact losses and eddy losses in the water during its passage through the turbine.

Another significant fact is the long range of gate openings for which an efficiency of over 80 per cent is obtained. In 1911 results of experiments were published showing the average efficiency of tests then on record to be 85 per cent. This value has been greatly exceeded, and a general increase of 10 per cent above efficiencies obtained twelve years ago can now be recorded.

The low-pressure Francis turbines used for heads up to 75 ft. are in Europe generally located in open flumes to which the water is conducted through an intake channel, the plant being arranged with vertical or horizontal shaft. The American arrangement for this class of turbine is generally a single vertical turbine, and the most notable developments in hydroelectric plants have been with this type of runner.

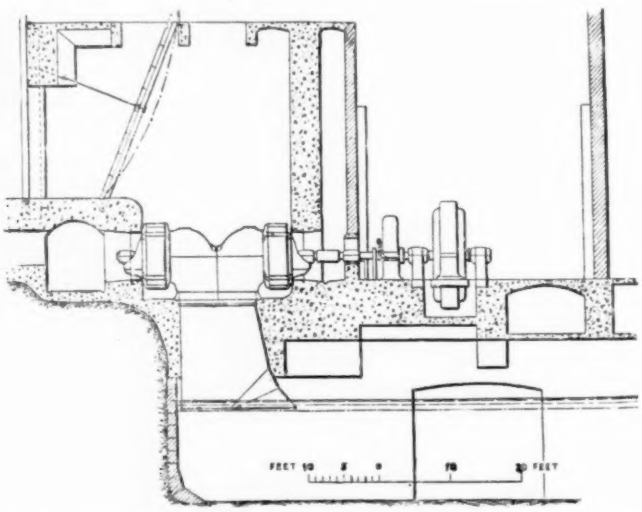


FIG. 2 HYDROELECTRIC POWER STATION AT FORSHULTEN, SWEDEN

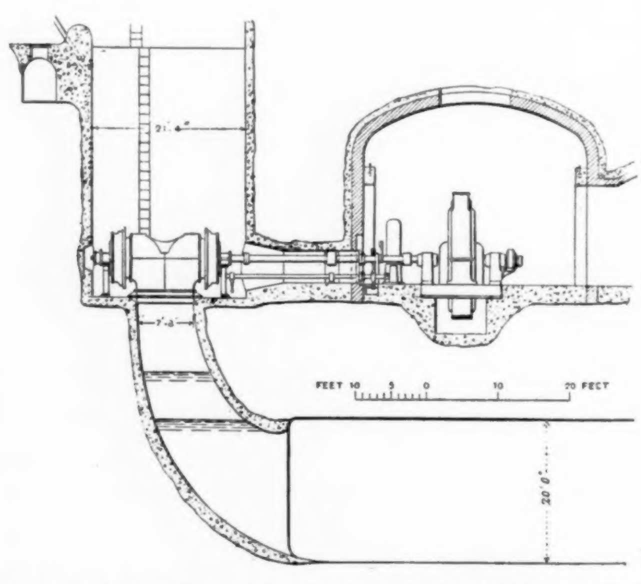


FIG. 3 MOCKFJAERDEN HYDROELECTRIC POWER STATION, SWEDEN

The power plant at Forshulten, Sweden (Fig. 2) is an example of a typical horizontal low-pressure turbine plant. The units, of which there are six in operation, each with an output of 3000 hp., are arranged with double runners on a horizontal shaft. They operate at 187 r.p.m. under a net fall of 42.6 ft., the wheels being placed in open concrete pits protected by sluice and strainer racks, the two runners discharging into a common cast-iron suction casing. The shaft is supported at each runner on two outside ring-lubricated bearings, in addition to a babbitt-lined automatically grease-lubricated bearing inside the suction casing. The practice of providing the turbines with lignum-vitæ underwater bearings has now been discontinued in favor of outside ring oil-lubricated bearings, the bearing on the inlet side being made accessible through an inspection tunnel as in the present case or through a vertical steel funnel protruding above high-water mark.

More than usual interest is presented by the arrangeemnt adopted at Mockfjaerden Hydroelectric Power Station, Sweden, on account of the power house being situated underground and using open turbines under the relatively high fall of 72 ft. The arrangement of the plant is seen from Fig. 3, and comprises four units each having an output of 5000 b.hp. at 225 r.p.m. with double runners on horizontal shafts. Each turbine is placed at the bottom of a concrete-lined shaft and discharges into the common tailrace tunnel. The powerhouse is blasted out of solid rock, the floor level being approximately 70 ft. below the surface, whereas the switchboard and transformers are housed in a separate building on ground level and communicate with the power house below through an inclined shaft. The alternators are directly connected to the turbine shaft and, due to the underground situation, special arrangements had to be made to insure sufficient cooling. For this purpose the alternators are totally enclosed and cold air is forced down a separate shaft and distributed through underground ducts to each alternator, the hot air escaping from the top of the housing and being expelled through the vertical shaft communicating with the surface.

Medium-pressure Francis turbines are classified by the author as those operating between the heads of 75 to 150 ft. A unique installation of this type of turbine is the Porjus Power Station, Sweden. As in the case of the Mockjaerden Power Station, this plant is also situated underground, but the turbines are enclosed in steel casings and placed at the bottom of the intake shafts about 160 ft. below ground level. The vertical shafts are cut through solid rock and provided with liners of steel pipes with an internal diameter of 11 ft. 6 in.; and with flanged connection to the turbine casing. There are five units with an average capacity of 12,500 hp. each under a net fall of 163 ft. running at 225 r.p.m. The turbines are of the double type with two runners, discharging into the common suction casing. The power house is also blasted out of solid rock, and is 36 ft. wide and 310 ft. long, communicating with the turbine chambers through the short tunnels which accommodate the shaft extension connecting turbines and alternators.

The roof is supported on a strong concrete arch, and by the provision of false walls and roofs leaving a space between the rock and the walls through which warm exhaust air from the generator is allowed to pass, all damp is prevented from penetrating into the power house. The generators have a normal output of 11,000 kva. and 10,000 to 11,000 volts 3-phase current. The necessary switchgear and transformers are also in this case placed in a separate building on ground level, a shaft providing communication between this building and the power house below, through which the heavy parts of the machinery can be lowered; in addition to which there is lift accommodation both for passengers and goods. The line voltage is 80,000, the power being utilized for railway traction and for mining purposes.

As an instructive example of the arrangement of the medium-pressure turbine with horizontal shaft and spiral casing, Fig. 4 shows a section through a unit of the Massaboden Hydroelectric plant used in connection with the Simplon Tunnel in Switzerland. Each unit is capable of developing 3500 b.hp. under a net head of 142 ft. at 500 r.p.m. The turbine is equipped with two runners cast back to back in one piece, the outside bearing being arranged with thrust collars to take up any unbalanced thrust in an axial direction.

The noteworthy fact with medium-pressure plants as in the case of low-pressure turbines, is that recent developments seem to favor single-runner units on account of higher mechanical overall efficiency and less foundation work, coupled with lower initial cost. The decision in each case must be made on its own merits and with a careful consideration of local conditions.

The outstanding feature in the development of the high-pressure Francis turbine is its adoption for use with increasing heads. To-

day Francis turbines utilizing a head of from 500 to 600 ft. are not uncommon, the highest fall for which a Francis turbine has been designed being approximately 745 ft.

The most important improvement in the Pelton wheel is in the system of regulation which was necessary for new conditions of electrical transmission, and the demand for accurate and reliable automatic governing. The inherent defect of the method of by-pass regulation being liability to stick and excessive wear, together with difficulty of insuring synchronizing action, resulted in the introduction of the deflecting nozzle. In recent years the combined spear and deflecting nozzle has come to the front and has now been adopted in most modern plants. A number of different designs of this method of operation can be traced to one of the three systems shown diagrammatically in Fig. 5. In each case the operating cylinder of the oil-pressure governor operates the deflector and spear simultaneously when opening, but by sudden closing of the governor the deflector will in the first instance cut into the jet and divert the water from the wheel until the spear by slowly overcoming the dashpot resistance, regulates the water supply corresponding to the load, when the deflector will be brought back into a position just tangential to the reduced jet. The free movement of the deflector, independent of the spear in the closing direction, is in each case permitted by the "lost motion" existing in the mechanical connection between the deflector and spear.

The principal development in the design of pipe lines has been the use of concrete for low-pressure lines where its low initial cost and durability give it a decided field of usefulness. In some places concrete pipes have been used as a pressure line when a special form of reinforcement and treatment to exclude leakage has been adopted. Wood-stave pipe line is of value because of its durability, low cost, and low coefficient of friction, and is therefore of practical advantage for the construction of the upper portion of pipe lines where suitable wood can be procured.

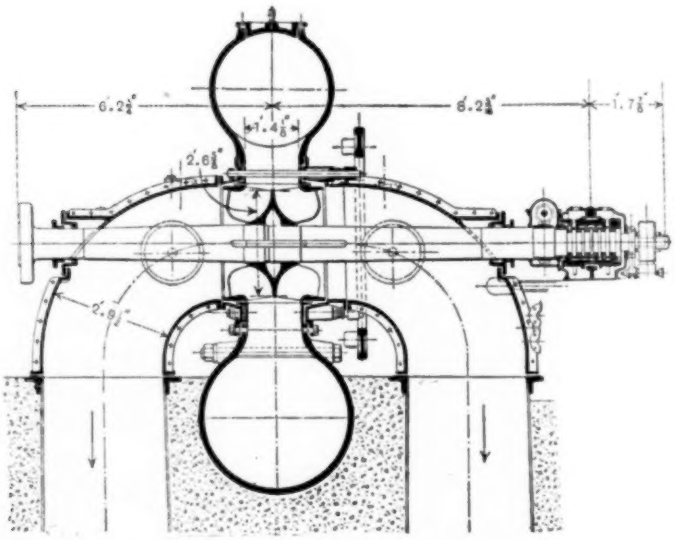


FIG. 4 ONE OF TWO TURBINES OF 3500 HP., MASSABODEN

The welded-steel pipe lines signify the most important developments in recent years because of the progressive utilization of high heads requiring close study of pipe-line construction. Welded pipe lines are exclusively used for high-pressure installations on account of their superior strength and absence of rivets which obstruct the flow of water. Welded pipes are heated by means of water gas and welded under high-speed, mechanically driven hammers which produce a weld of approximately 95 to 97 per cent of the strength of the full plate. After welding the pipes are annealed to remove all internal stresses. The foregoing process is only suitable for material up to about 1¼ in. thick, as above this thickness the heat would not penetrate sufficiently to produce a uniform welding heat. For larger plate thickness, the "wedge-welding" method is resorted to, the edges being brought together and a separate bar inserted, forming the weld. With this method pipes up to a thickness of 1¾ in. can be satisfactorily welded. The material used in welded pipe lines is best open-hearth steel, with a tensile strength of 56,000 lb. per sq. in. and a elongation of 20 to 25 per cent in 8 in. On account of pressure surges plate thicknesses are calculated with a factor of safety of from 4 to 5, based on the strength of the weld equal to 100 per cent. Pipes are made in lengths of an average of 18 to 20 ft., using riveted joints for medium pressures and flange or expansion joints for high pressures. In the riveted, or so-called

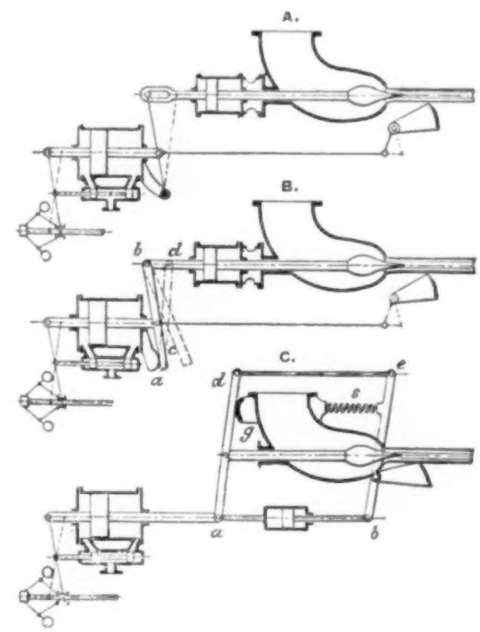


FIG. 5 SYSTEMS OF REGULATION FOR PELTON WHEELS

"bump" joint, the pipe ends are swelled so that the rivet heads do not obstruct the free area of the pipe.

A further improvement in the art of welding is reinforced welded pipe, consisting of a number of solid forged rings shrunk on to the outside of the pipe and adding further strength to the pipe with a reduction of plate thickness. This innovation in pipe design permits, for high heads, the use of a larger-diameter pipe without exceeding the maximum limit of plate thickness to obtain a reliable weld, thus reducing the number of pipe lines for large installations and the initial cost of installation. Although the present method of manufacture permits only short lengths of reinforced pipe to be made, these may be welded together with a circumferential weld into lengths of about 18 ft. In high heads this method of pipe-line construction makes an appreciable reduction in the initial cost of the development.

In his conclusion, Mr. Bergstrom shows the results of an estimate of the available horsepower in the principal countries of Europe and America. In the United States 28,100,000 hp. are shown as available, 24.9 per cent of which has been developed; 2,000,000 in Switzerland, of which 25.5 per cent has been developed; 4,000,000 in Italy, of which 24.4 per cent has been developed. Lowest percentages of development have been in Great Britain, with 8.3 per cent of 963,300 hp.; Spain, with 8.8 per cent of 5,000,000 hp.; and Austria-Hungary with 8.8 per cent of 6,460,000 hp. These figures apply, as stated above, only to Europe and the United States of America, and do not include the vast resources in white coal of Australia, Asia, Africa and the South American continent. (*Journal of the Institution of Mechanical Engineers*, Feb. and Mar. 1920, pp. 55-151, 51 figs. Also in *Engineering*, Jan. 30 (pp. 140-143), Feb. 6 (pp. 191-195) and Feb. 13 (pp. 227-232), 1920, from which journal the illustrations here used have been reproduced.)

The Kaplan Hydraulic Turbine

THE Kaplan turbine, designed by Professor Kaplan of Brünn, Austria, is a development of the Francis type. In a Francis turbine the water acquires a certain predetermined velocity and direction, and then flows under the turbine wheel where it is deflected by the runner blades in such a manner as to pass into the suction pipe as far as possible without loss. The Francis turbine belongs to the class of pressure turbines; that is, the water possesses a certain excess pressure before it enters into the turbine wheel, and the pressure head is only partly converted into velocity in the guide apparatus.

The efficiency of the turbine depends, therefore, upon the blade angle and this latter in its turn is determined by the necessity of providing for the entrance of water as free of shock as possible. This again is accomplished when the runner blades are inclined with respect to the circumference of the runner in the direction of the flow of the entering water. In other words, if the water (Fig. 1) enters from the guide apparatus into the runner with the velocity of w_1, then it has only a velocity v_1, relatively to the runner moving with the peripheral velocity μ_1. The angle between μ_1 and v_1 is the true angle of entrance with respect to the runner blade. By varying this angle, it is possible to vary the velocity of rotation of the turbine within certain limits, acute angles giving low velocities of rotation, and large angles high velocities of rotation, while the so-called normal runners require right angles. In addition to this, slow-running turbines are built with runners of as large a diameter as possible, and fast-running turbines with runners of small diameters. In this way various types of turbines with their characteristic design are secured, and the original article gives illustrations of two such runners, one for slow speed and one for high speed.

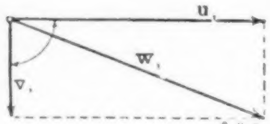


Fig. 1 Velocity Diagram of Medium-Speed Francis Turbine

It has been usual heretofore in designing the runner blades to divide the turbines into so-called elemental turbines and to determine the proper dimensions of cross-sections for each line of flow, assuming the flow to be as free as possible from losses.

It is claimed that Professor Kaplan has entirely deserted all these rules based on the so-called theory of "water-filament flow." He, in his theory of turbine design, attaches as much importance to the question of friction, which has been hitherto practically neglected, as has been done by others to the character of flow. According to his theory, other conditions being similar, it is the number of blades that has the determining importance. If it is too small, the flow of water suffers, and if it is too large, then the efficiency is reduced.

In an effort to create a turbine of maximum speed Professor Kaplan in the first place shortened as much as possible the length of the blades. Furthermore, he found that a large runner clearance does not harm in any way. This led him to locate the blades further and further back of each other until he obtained a runner having only actual flow. Finally, it is claimed that he succeeded by proper selection of the suction pipe in reconverting a large amount of the energy of the water at discharge into pressure.

All these changes led to the design of the new form of turbine such as is shown diagrammatically in Fig. 2. Contrary to what happens in a Francis turbine, the water flows throughout through the runner in an axial direction and the deflection of the water in the runner is eliminated. The guide apparatus is designed in the same manner as in the conventional Francis turbines, but the vanes are so arranged that the water discharges not only along the longitudinal edges, but also at the front edges. The guide-wheel cover has been made flat. According to the prevailing opinion, the water left to itself after its exit from the guide apparatus should lose most of its velocity through turbulence in the annular space formed by the flat cover, and at first glance it would appear that the dead space at E would unfavorably affect the flow of water. The two lines of flow S_1 and S_2 show, however, in what a powerful manner the water is deflected between the guide wheel and the runner.

It is claimed that the Kaplan turbine has several advantages of design, of which the following may be mentioned:

The turbine shaft can have its bearings located nearer the center of gravity of the runner than is the case in the Francis turbine. This results in a stable, comparatively light construction, avoiding the difficulties due to unbalancing which are encountered in Francis high-speed turbines.

The runner is somewhat smaller in diameter than the draft tube at its narrowest place. This makes it possible to insert the runner into the casing both from the draft-tube side and from the guide-wheel cover side, contrary to what is the case with high-speed turbines, which can be installed only from the draft-tube side, which is not always easy to do.

The diameter of the runner boss can be kept comparatively small; likewise the free blade area F is considerably smaller than in the Francis turbine. The weight of the Kaplan runner is therefore very much smaller, in fact, it is claimed to be

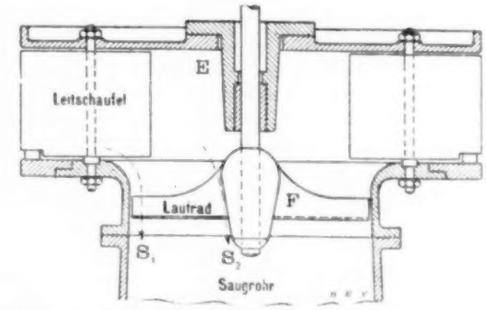


Fig. 2 Sectional View of a Kaplan Turbine
(*Leitshaufel*, guide vane; *Laufrad*, Runner; *Saugrohr*, Draft tube.)

on the average only about one-fifth of the weight of a Francis wheel of the same diameter. Furthermore, the difficult method of holding the blades is eliminated, as a result of which it is claimed that a Kaplan runner can be made in about one-fourth the time required to make a Francis runner.

The principal advantage of the new construction is claimed to lie, however, not in these advantages affecting construction, but in the fact that with a Kaplan turbine speeds become attainable which are beyond the capacity of the Francis turbine, in addition to which the efficiency of the turbine at various loads varies in a more advantageous manner than with the conventional turbines. These points are further elucidated in the following manner:

It is important to have hydraulic turbines run at as high a speed as possible, because this permits a more economical utilization of the electrical generators usually connected to them; and it appears that the most economical speed of rotation for the generator is from 200 to 300 r.p.m. for power outputs of from 500 to 5000 hp., and from 400 to 600 r.p.m. for power outputs of from 100 to 500 hp.

These speeds are beyond the range of Francis turbines, unless the head of water is very large and the volume of water small. This results in uneconomical plants for low water heads, and in illustration a calculation is given showing that in a low-head plant with a turbine having an output of 5000 hp. and running at 83 r.p.m., the generators at peace-time prices would cost 150,000 marks (say $37,500), while if the turbine could be run at 250 r.p.m. the cost of the generators would be only 100,000 marks (say $25,000). Furthermore, the high-speed turbine, all else being equal, would be built much cheaper than the low-speed machine.

The low-speed machine is uneconomical from another point of view: namely, that where large volumes of water have to be handled a large number of units have to be used, since otherwise the velocity would have to be excessively low and the units excessively large. Numerous small units, however, are always more expensive than a few large ones.

A good insight into the question of the speeds available with various turbine types is obtained by employing the conception of "specific speed," which may be called "unit speed." In this the volume of water handled and the head of water for a given turbine are eliminated, and a unit speed determined for a given type of runner. By such a unit speed is understood the speed at which a machine similar in construction to the given turbine would have to run when delivering 1 hp. under a head of 1 m. If a turbine delivering N hp. with a head of H runs at n revolutions per minute, its unit speed of rotation is

$$n_s = n \frac{\sqrt{N}}{H\sqrt{H}}$$

The following unit speeds are given for the conventional types:

12 to 50 for Pelton wheels
50 to 100 for Francis slow-speed wheels
100 to 200 for Francis normal-speed wheels, and
200 to 300 for Francis high-speed wheels.

As compared with these, a very much higher figure is possible with the Kaplan turbine: The first of these turbines built in Sweden had unit speeds of from 500 to 600, the turbine tested at the Technical High School in Brünn, 900, and in recent tests speeds of 1200 to 1600 have been obtained with good efficiency.

Efficiency of Turbines

Francis turbines have a very high efficiency, exceeding 80 per cent. This efficiency depends, however, on the type of the turbine, high-speed turbines having usually poorer efficiency than low-speed. Fig. 3 shows how the efficiency varies at various loads for a Francis turbine running with a unit speed of about 200. As is usual, this turbine has been designed to work with an average volume of water equal to three-fourths of the maximum volume, and at 0.75 load it attains its highest efficiency, which falls off materially with smaller load.

If this is compared with the brake diagram of a Kaplan turbine built in Sweden (Fig. 4), it can be seen that notwithstanding the high unit speed, namely, 750, the efficiency is not only very good in itself, but remains practically the same over a range of from about one-half to full load.

In this connection the curve shown in Fig. 5 is of considerable interest. This was secured from a brake test of a turbine installed in lower Austria and designed to operate at a unit speed of rotation of about 700. The wheel has a diameter of only 600 mm. and was designed to deliver about 35 hp. with 1.1 cu. m. of water per second and a head of 3 m. As shown by the curve, the efficiency rises from full load to one-half load, and even at 40 per cent. of the specified volume of flow it is still close to 83 per cent. Brake tests were made on the turbine under the same load but with various heads of water and various speeds of rotation and these tests have also shown a remarkable uniformity in efficiency.

This lack of sensitiveness of the Kaplan turbine to variations in the volume of flow and in the head is particularly important in low-head installations, as it makes it possible to build the turbine for the maximum available volume of flow and then operate on smaller volumes and yet attain a high efficiency. In addition to this, it is not necessary to go to the trouble of providing high-water reserves as the Kaplan turbine can very well stand overloads.

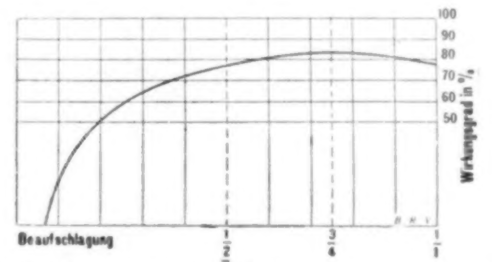


FIG. 3 EFFICIENCY OF A FRANCIS TURBINE $n_s = 200$

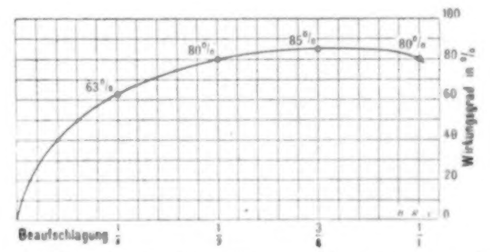


FIG. 4 EFFICIENCY OF A KAPLAN TURBINE $n_s = 750$

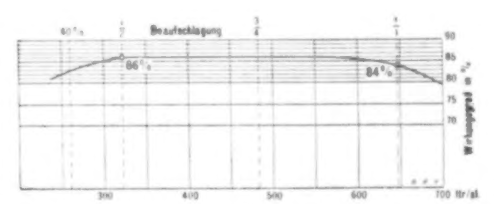


FIG. 5 EFFICIENCY OF A KAPLAN TURBINE $n_s = 700$

(*Beaufschlagung*, load; *Wirkungsgrad*, Efficiency; 1*tr./sk.*, liters per sec.)

An interesting feature of this type is that in many cases it is very easy to convert a conventional Francis turbine into a Kaplan turbine, for only the runner has to be changed, the guide apparatus remaining the same. (*Zeitschrift des Bayerischen Revisions-Vereins*, vol. 24, no. 9, May 15, 1920, pp. 71-73, 7 figs.)

Hydraulic Section of Report of the National Electric Light Association Committee on Prime Movers

THE important feature of the past year's development is the increased size of water wheels installed. The growth of operating systems makes feasible this increased size, individual units of approximately 40,000 hp. capacity having been installed and larger ones being contemplated. One large manufacturing company reports the starting of a total of nearly one-quarter of a million kilowatts in large hydroelectric generators in units of over 12,000 kw. each. In addition there are a large number of smaller vertical direct-connected wheels being installed as additional or replacement units.

Progress and Development of Hydraulic Prime Movers

The tests of the large water wheels in place show remarkably high efficiency, which makes it profitable in a great number of cases to replace old installations with new. The new large units are uniformly distributed over the United States. Many of the older hydraulic developments which used dams and canals, supplying widely scattered individual water wheels, are now planning a single hydroelectric station to utilize the entire fall and transmit the power electrically.

Several large units have been started and continuously operated for over a year without a single shutdown on account of wheel troubles.

A new type of water wheel for low-head plants using an exceptionally high-speed runner has been developed by Forrest Nagler of the Allis-Chalmers Company.

Four 15,000-hp. tangential wheels for operating under an effective head of 1008 ft. have been ordered by the Great Western Power Company. These wheels contain 21 buckets, each 36 in. wide and 24 in. deep, and water is supplied from 13 nozzles. They are to operate one each overhung from the ends of a 22,200-kva. generator shaft running at a speed of 171.4 r.p.m. It may be of interest to state that several water-wheel manufacturers designed and recommended Francis-type wheels for this head at a speed of either 600 r.p.m. or 750 r.p.m. The operating engineers, however, were afraid that the erosion on the clearance passages and gate mechanism might be rather severe when operating under a pressure of over 430 lb. per sq. in. This, coupled with the fact that it would require a turbine-type generator with smooth-core field which was not suited for charging conditions on their long transmission line, led them to choose the impulse wheel.

There are at present under construction some 800-ft. Francis wheels for the Southern California Edison Company, to be run 600 r.p.m. and deliver a maximum horsepower of 22,500.

Automatic hydroelectric plants are receiving considerable attention. These plants operate without attendants, and the gate openings and output are regulated according to the water supply available, by means of a float control from pond level. These plants may be tied into a local power system or be run in connection with a steam station which takes care of the fluctuation of load and varying flow of stream.

There is a radical tendency, where climatic conditions are favorable, to confine the power-station building to the housing of control apparatus only, locating generating apparatus, step-up transformers and high-tension equipment outdoors.

General practice is divided between the centralization of auxiliaries and a tendency to make each large unit self-contained with its own exciter, governor, pumps, etc. A satisfactory solution of this problem is accomplished by having individual speed-control sets for each of the main units and by having an emergency pipe connection from each individual set to each adjacent set. Each main oil-pressure set is of sufficient size to operate two main units under emergency conditions. Thus all of the advantages of the central oil-pressure system are combined with the advantage of the individual system.

Hydraulic Operation and Combined Operation of Hydraulic and Steam Plants

The combined operation of hydroelectric and steam-electric generating stations has become a subject of vital interest to the central-station industry. It will be increasingly important in the future, since the marked trend toward interconnection will bring more and more steam plants into parallel operation with hydraulic plants, and will make possible the development of water powers which cannot now be utilized economically. Yet intensive study of the subject is comparatively new. Individual companies and systems have made more or less careful analyses of their own conditions and problems, but there has been little information exchanged or published. During the past year the committee has considered or has had brought to its attention a large number of problems. These are listed below with the idea of having before the committee an outline to be followed in future work.

The problems of combined operation and hydraulic operation may be classified under the three heads outlined below: namely, (1) problems of the combined system; (2) problems of the steam plant; (3) problems of the hydraulic plant. Some problems of purely hydraulic operation are included in the third group, although they do not depend on combined operation.

I—Problems of the Combined System:

A—Parallel operation of coöperative systems:

1 Contract relations between hydraulic and steam plants
2 Advantages and disadvantages of interconnection
3 Division of load between hydraulic and steam plants
 (*a*) High-flow operation
 (*b*) Low-flow operation
4 Division of wattless current between hydraulic and steam plants
5 Frequency regulation and governing
6 Relative reliability of hydroelectric and steam-electric service.

B—Parallel operation of non-coöperative systems:

In this group there are other problems which are chiefly electrical and do not fall within the scope of the Prime Movers Committee, but it should be mentioned that a complete study of combined operation would include the following problems: Increased damage to property and interruption to service which may result from greater capacity feeding in so short-circuits; protective methods; the use of reactance to limit short-circuit currents; the effects of such reactance on voltage and synchronizing power; voltage regulation; synchronizing power of tie lines.

II—Problems of the Steam Plant:

1 Standby service
2 Minimum load on steam turbines
3 Time required to start up steam turbines
4 Shutting down steam plant during "off-peak" hours
5 Banking practice as related to combined operation
6 Novelties and difficulties in operating
7 Station design as affected by combined operation.

III—Problems of the Hydraulic Plant:

1 Efficiency measures to secure maximum output or water economy.
2 Measurement of water
3 Dispatching of water and hydrographic methods
 (*a*) When the water is used by only one plant
 (*b*) When the same water is used by two or more plants
4 Ice troubles and methods of fighting same
5 Power requirements and operation of auxiliaries
6 Planning of maintenance, inspection, and repairs
7 Operating rules and procedure
8 Novelties and troubles in operating
9 Station design as affected by combined operation.

From this analysis of the problems of the combined operation the report considers the points in detail, outlining the information required for further reports and giving some data that have been discovered in the solution of the subdivisions of the problems. The report states that every system must constitute a separate problem, but it is believed that many principles and conclusions will have a common application to a large number of systems. In abstracting the remainder of the report, material will be included only where new information has been submitted.

I—Problems of the Combined System: A—Parallel Operation of Coöperative Systems

1 *Contract Relations Between Hydraulic and Steam Plants.* The ideal in every combined system should be minimum overall cost of delivery to the ultimate consumers. The solution of the problem, where hydraulic and steam stations are separately owned, lies in some sort of flexible arrangement on a coöperative or cost- and profit-sharing basis in which rigid limits of power and energy are disregarded and the maximum output of the hydraulic plant is utilized as far as possible. Such a solution furthers the conservation of our natural resources in which the central-station industry is vitally interested.

3 *Division of Load Between Hydraulic and Steam Plants.* Under this head the report calls attention to some instances where steam generation is necessary in spite of the fact that the hydraulic plant is carrying the load. Such steam generation may be necessary for maintenance, economy or safety of steam-plant equipment, or reliability of service. Unnecessary steam generation may be caused by faulty governing or load dispatching. Under a discussion on the unnecessary steam generation due to faulty governing or load dispatching, the report points out the necessity for a graphic meter giving total station out-

put for each generator station, and the necessity of means of communicating output figures from all generating stations to one central point.

The importance of not having the hydraulic capacity of the turbine limited by the generator capacity is also emphasized.

4 *Division of Wattless Current Between Hydraulic and Steam Plants.* In the case of a hydraulic plant operating in parallel with the steam plant, the problem consists of comparing aggregate steam costs for high load factor but increased steam generation due to hydro losses, with steam costs for a poor load factor but a smaller amount of energy output. If the hydro plant has large storage or high head and little tailrace backwater, so that the reduction in head due to low load factor is not great, it will usually be found that it is most economical for the hydro plant to take the poor load factor. The result may be reversed if the percentage loss of delivered output from the hydro plant is considerable and if the percentage increase of steam costs due to lower load factor and variations is negligible.

6 *Relative Reliability of Hydroelectric and Steam-Electric Service.* The report is quite positive in its statement that in recent years particularly, the individual hydraulic prime mover is more reliable than the individual steam turbine. The present-day single-runner vertical-type water-wheel-driven generator equipped with a Kingsbury bearing seems to give almost perfect continuity of service. It has been nearly always found that hydro service can be restored before the steam plant can pick up a large proportion of the load even with a number of boilers held ready under "hot bank." As a result, with modern conservative construction of transmission lines, there is very little pure stand-by service in the East and Middle West. On the Pacific Coast, where use of fuel oil makes quick firing possible and transmissions of great length with considerable inherent voltage drop, extensive stand-by service is more common.

II—Problems of the Steam Plant

1 *Stand-by Service.* It is stated that in coal-burning plants underfeed stokers with forced draft and fan and ram speed control, or chain grates with forced draft may be found most satisfactory for quick starting. Future developments will be along the line of using oil and coal under the same boiler, and of adapting pulverized fuel for large central-station use.

The example of the municipal plant of Zurich, Switzerland, is cited as demonstrating that during off-peak hours stand-by boiler pressure may be supplied electrically from the hydroelectric plant. In this case, the use of electricity for which there was no market was more economical than paying for banking coal.

2 *Minimum Load on Steam Turbines.* Motoring, even with a certain amount of steam entering the turbine, dropping below a certain minimum turbine load, and sharp fluctuations of load are regarded as injurious to large high-speed steam turbines by many operating engineers in Eastern plants.

On the Pacific Coast, however, the steam turbines have been floated on the line with practically no load, and in some cases, as synchronous condensers, with less than no load steam entering the turbine without apparent damage.

4 *Shutting Down Steam Plant During "Off-Peak" Hours.* To avoid the difficulties caused by accumulation of water in pipe lines and leaky joints, occurring in the steam plant during shutdowns, some plants operate at least one boiler at near normal rating during the off-peak hours and use the steam thus generated to operate a small unit, circulating the steam through all the steam mains before it reaches the unit. In other cases the generating plant is shut down entirely, but steam is blown off for some time near the turbine inlet before the unit is started up.

5 *Banking Practice as Related to Combined Operation.* A steam plant carrying the peak loads of a combined system operates at a poor load factor and therefore has an increased amount of banking. The report gives the result of a 42-hour banking test on a 822-hp. Stirling boiler with underfeed stokers as 0.112 lb. of 13,500-B.t.u. coal per rated boiler hp. banking hour. The pressure being allowed to drop about 15 lb. below normal, coal was added after 16¾, 23¾ and 40 hours. The steam generated after the bank had nominally begun was approximately measured and an equivalent amount of coal deducted. In a similar test on oil-burning boilers a value of 0.046 lb. of oil per hp-hour was found. This is equivalent in heating value to 0.063 lb. of 13,500-B.t.u. coal.

6 *Novelties and Difficulties in Operating.* The percentage changes in load on steam plant are very greatly increased when the hydro plant takes flat load during high flow. This condition makes a foreknowledge of load variations essential to avoid excessive blowing off through safety valves or reduction of hydraulic output. To assist in estimating load in the boiler room, the Ashley Street Station of the Union Electric Light and Power Company of St. Louis operating in parallel with the Mississippi River Power Company and equipped with a number of varying sizes and types of generating units of which a kilowatt load does not give an accurate idea of the boiler room, has adopted a novel unit called the "kilber." The kilber is 1000 lb. of steam per hour. The boiler room is regulated by the number of kilbers required, an estimate which is furnished from the switchboard at half-hour intervals.

III—Problems of the Hydraulic Plant

1 *Efficiency Measures to Secure Maximum Output or Water Economy.* The report contains a detailed consideration of the operation of the Holtwood Station for information under the above heading. This station operates most of the time in parallel with one, frequently two, and rarely with three, steam-generating stations. Energy is transmitted at 70,000 volts to Baltimore, Md., 40 miles distant, and to Lancaster, Pa., 15 miles distant.

The Holtwood Station is on the Susquehanna River, the flow of which varies from about 3000 to about 700,000 cu. ft. per sec. The average height of the dam is about 55 ft. and flashboards of a height of 2½ ft. or 4½ ft., according to the season, are usually installed on the crest. Except during high floods and extreme low flow, the working head varies from about 47 ft. to 62 ft. The area of the pond at the elevation of the dam crest is less than four square miles. There are eight main turbines of the vertical-shaft, inward and downward flow Francis type. The total of the turbine ratings is 118,000 hp. (ratings are not, however, at the same head). The actual maximum sustained capacity of the plant is about 83,000 kw. Seven of the turbines are set in wheel pits with two runners per shaft. The eighth and newest unit is a single-runner turbine set in a reinforced-concrete scroll case.

Tailrace conditions are such that, with no flow over the dam, the tailrace elevation at the power house is about 14 ft. higher at full load than at no load. (*Report of Committee on Prime Movers*, presented at 43d Convention of the National Electric Light Association, May 18-22, 1920, pp. 105-128.)

Short Abstracts of the Month

ENGINEERING MATERIALS

Study of Impact Tests on Alloys, Austin B. Wilson. Impact tests are of interest as comparatively little is known of the properties of metals under this type of stress. In the present case tests were made of three distinct classes, namely, McAdam impact-shear tests with unnotched bars, Fremont direct impact tests with notched bars, and Landgraf-Turner alternating-impact tests.

Several series of tests of each kind were made. At first machined bars were used, but the tests indicated that it was not necessary to machine the bars. Second, the bars were heat-treated by quenching from 920 deg. cent., reheating to 600 deg. cent., and furnace-cooling. This, it was thought, would increase the resistance to impact-shear, but such was not the case. In

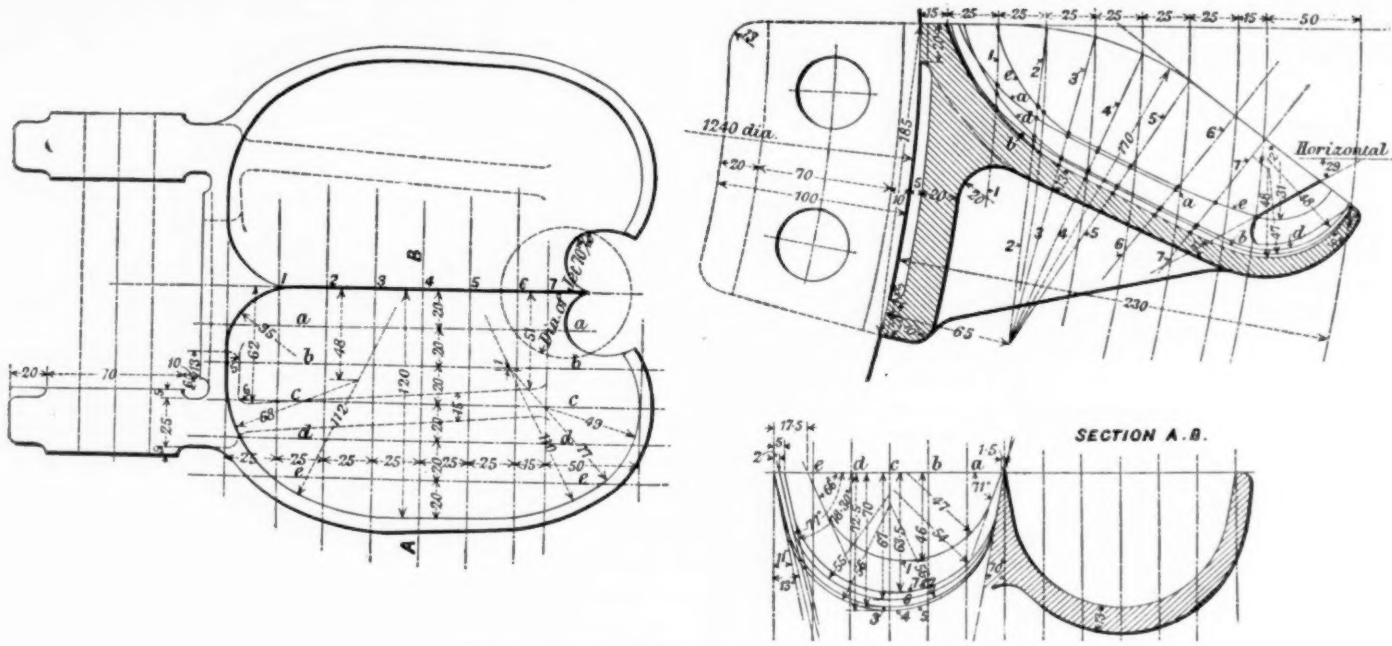


FIG. 1 LAYOUT FOR PELTON TURBINE BUCKETS

general, it was found that the aluminum bronzes tested excelled any of the other bronzes of the series in resistance to impact by shearing.

Aluminum bronze also showed high resistance to direct impact where *notched* effect was present; likewise it surpassed other bronzes in resistance to failure through fatigue.

Data of the tests are presented in the original article in the form of tables but no analyses of the materials tested are given. (*Foundry*, vol. 68, no. 352, August 1, 1920, pp. 616-617 and 622, 3 figs., *e*)

HYDRAULIC ENGINEERING

Pelton-Wheel Bucket Design

PELTON WHEEL RECONSTRUCTION, Percy Pitman. Description of a reconstruction carried out during the war period. The work was difficult as it had to be carried out on the turbine as it stood in the power house and only the top cover could be removed, which made the position in which to work very cramped.

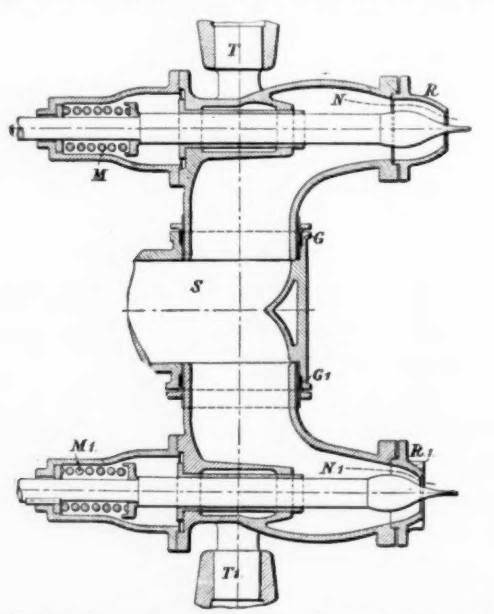


FIG. 2 PERCY PITMAN GOVERNOR FOR PELTON WATER TURBINE

The turbines were of the Pelton type made by Ganz and Company of Budapest, and were installed in 1907, to work with a head of water of 1010 ft. Each Pelton wheel consisted of two 4-ft. diameter steel disk runners and each wheel was fitted with 22 staggered buckets. Both the buckets and the needle and nozzle were of an extremely bad shape and were continuously breaking, which was particularly dangerous in view of the high peripheral velocity employed.

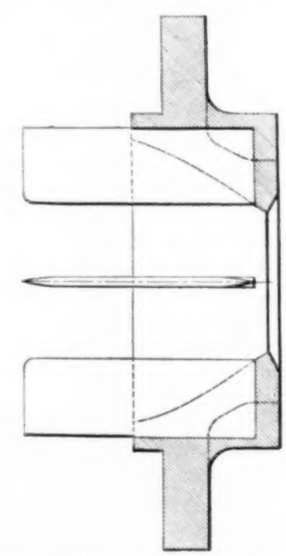


FIG. 3 EXPERIMENTAL NOZZLE FOR USE IN PELTON WATER TURBINE

The portion of the paper describing the new installation is of particular interest because it presents a complete layout for the new buckets, a thing not often found in engineering literature.

The bucket, Fig 1, is of the usual Pelton shape with the exception that it is slightly curved on the dividing wedge, and also on the bottom face of the bucket in a radial direction. The purpose of this is to give a larger radius of effective action after the bucket has passed the theoretically best position; that is, when the bucket face is at right angles to the entering stream.

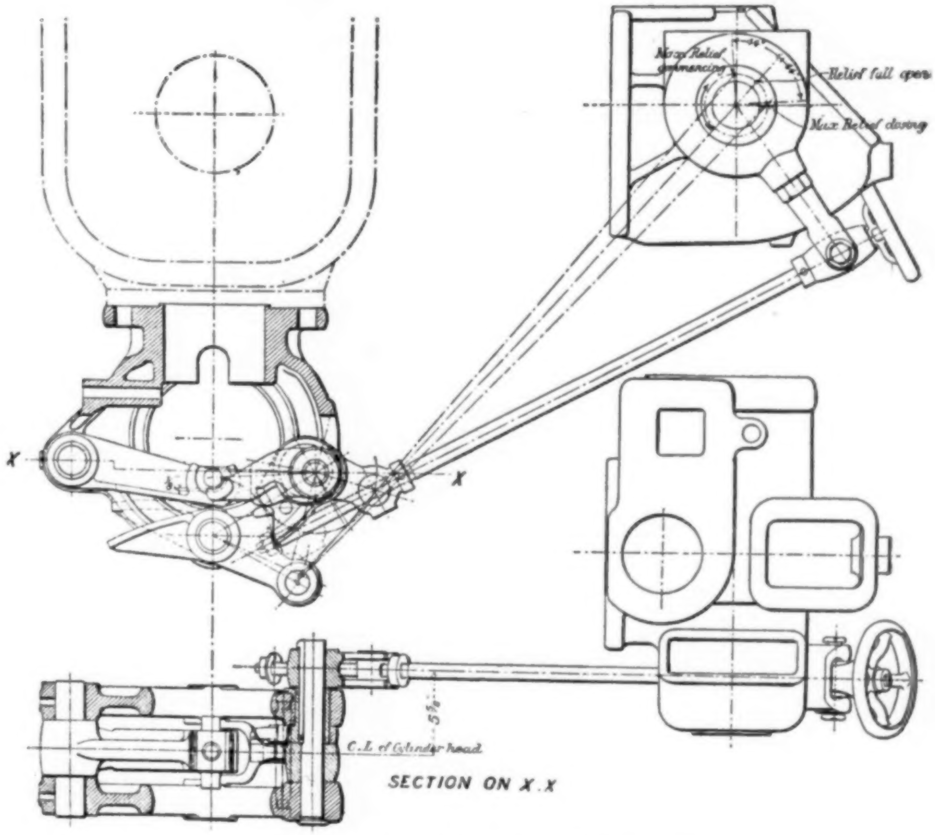
The drawings show the points from which the various radii are struck. The methods of setting out shown are applicable to almost the whole range of impulse waterwheels, providing load conditions, head of water, size of nozzle, and speed required are taken into consideration.

The author designed a separate governor for the automatic regulation of the needles to enable the plant to take care of load changes, and at the same time economize water. This is shown in Fig. 2. The bad stream lines made by the existing steel nozzles R are shown by dotted lines N. The new bronze nozzles R_1 give a much straighter path N_1 through the nozzles. T and T_1 are the trunnions and G and G_1 the glands, while S is the T-shaped supply pipe. The springs M and M_1 shown in Fig. 2 were designed to improve matters, but unfortunately up to the present the plant could not be spared the necessary length of time to carry out such a desirable improvement. The old Ganz buckets, needle and nozzle with 420 lb. pressure on the gage gave 970 kw. corrected, and the new buckets with the existing steel nozzle and spear (which was not made by the writer) gave 1082 kw., and after allowing a substantial correction factor of 4 per cent, it showed an increase of 70 kw., or a net increase in efficiency of 7.3 per cent.

Experimental nozzles were also made of bronze, into which were dovetailed four rustless-steel blades which were ground and highly polished up to a thin knife-edge on the inside, as shown in Fig. 3. These nozzles proved to be a big improvement, producing a jet of extraordinary solidity and transparency, the water for about 2 ft. issuing almost like a glass rod. The electrician in charge of the power station claimed that there was an increase of efficiency of 5 per cent due to this improvement.

Ordinarily the swinging or rotative character of the stream produced great vibration which seems to have produced fatigue of some sort in the steel blades, causing them to break off short at different intervals after they had been in use for some months.

An intensive analysis of the defects of the turbine as it existed previous to reconstruction is given in the original article. (*Engineering*, vol. 109, no. 2843, June 25, 1920, pp. 851-853, 13 figs., *dp*)



FIGS. 4 AND 5 FUEL PUMPS AND VALVE GEAR

INTERNAL-COMBUSTION ENGINEERING

Cold-Starting Oil Engine

SOLID-INJECTION RUSTON AND HORNSBY CRUDE-OIL ENGINE. The Ruston and Hornsby engine is of the so-called cold-starting type, and depends upon the heat of compression for the ignition of the charge. It is claimed that a fuel consumption of below 0.4 lb. of fuel oil per b.hp. at full load has been obtained without difficulty.

The engines are built of the single-cylinder type in 11 sizes, ranging from 15 b.hp. to 170 b.hp., and of the double-cylinder type in 5 sizes, from 100 b.hp. to 340 b.hp.

The fuel pumps and valve gear for both cylinders are driven from a single lay shaft running along the right-hand side of the engine, the eccentric operating the inlet, and exhaust valves being keyed on the extreme end of this shaft. The motion of the eccentric is transmitted to the valves by means of rolling levers (Figs. 4 and 5) which give a more rapid opening and closing motion than would be obtained by the eccentric motion alone. The small handwheel seen near the eccentric is for the purpose of relieving the compression by raising the exhaust valves slightly from their seats.

When working with the lowest grades of tar oil, it is necessary, in order to insure proper ignition of the charge, to inject just ahead of the main charge a very small quantity of crude or other more inflammable oil. This only amounts to

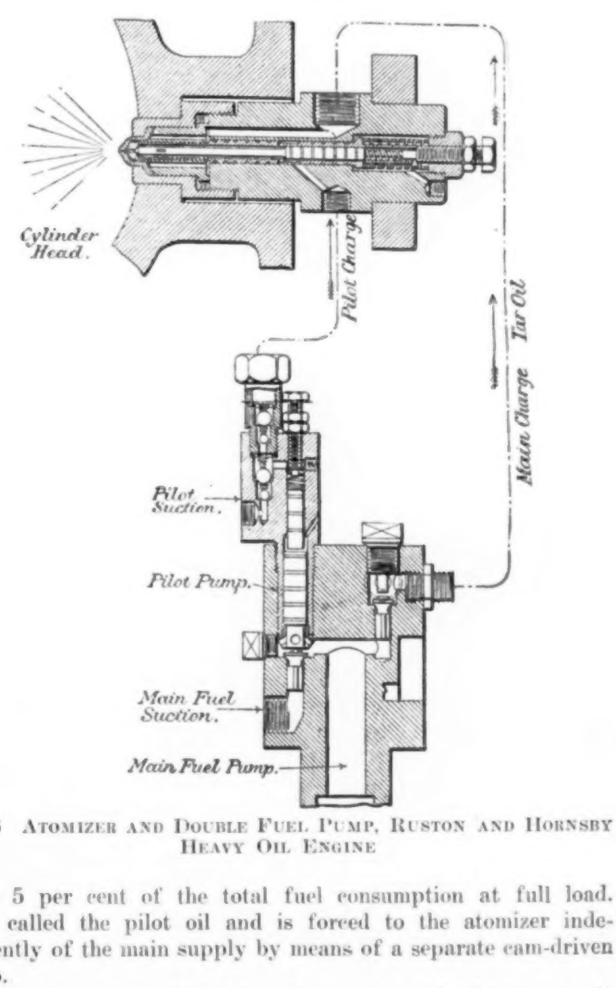


FIG. 6 ATOMIZER AND DOUBLE FUEL PUMP, RUSTON AND HORNSBY HEAVY OIL ENGINE

about 5 per cent of the total fuel consumption at full load. It is called the pilot oil and is forced to the atomizer independently of the main supply by means of a separate cam-driven pump.

The construction of the atomizer and double fuel pump is

shown in Fig. 6. The single main pump primarily deals with the main supply of tar oil. It takes in fuel through the main suction valve and delivers it to the atomizer through the discharge valve in the usual way. The by-pass valve controlled by the governor is not shown.

Above the main suction valve is the pilot valve, which consists of two plungers of different diameters, the lower and larger one being acted upon by the pressure of the main fuel. At every stroke of the main pump the upper and smaller plunger is raised against the action of the spring by the pressure of the fuel oil on the lower one. The upper plunger therefore acts as another pump on its own account, and by means of its own suction and discharge valves it forces the pilot oil through the atomizer separately from the main supply.

With such an arrangement the amount of pilot oil delivered at every stroke can be regulated by varying the stroke of the pilot pump. Also, the pilot oil is necessarily injected immediately in advance of the main fuel oil, which is the required condition. (*Engineering*, vol. 110, no. 2844, July 2, 1920, pp. 7-10, serial article, 22 figs., *d*)

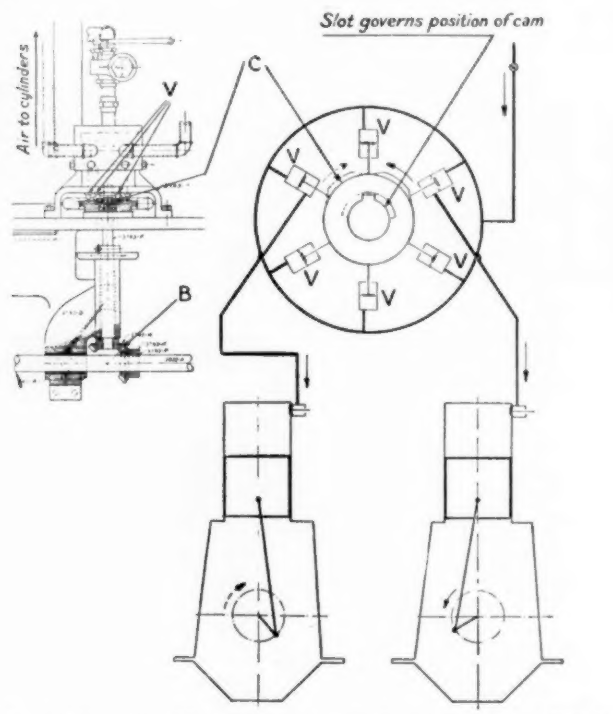


Fig. 7 Air-Starting Mechanism of the Ingersoll-Rand P-R Oil Engine

American Heavy-Oil Engine, Intermediary Between Diesel and Semi-Diesel

Ingersoll-Rand P-R Oil Engine. These engines are of the heavy-oil type and yet neither straight Diesel nor hot-bulb. The P-R is of the low-compression self-igniting type, but without hot plate or hot spot.

The engine is started by compressed air through a distributor (Fig. 7) which consists of six air valves *V*, one for each of the cylinders. Below these air valves is a cam *C* which is operated by a gear *B* from the side shaft. When the air is turned on, the six valves are driven down by the air against the action of springs and are closed, with the exception of one valve which strikes the top of the cam. This valve being held open by the cam, permits the air to pass to the cylinder which it controls. The engine turns in a given direction and the cam likewise turns, opening each valve in succession. To reverse the engine, it is stopped, the cam is moved to its opposite position, and the air valve opened.

When the engine is absolutely cold, the ignition at the start is assisted by means of a small electrical starting element located in the combustion chamber and heated to a dull red. This heating element is used only for a few revolutions and then discontinued. It does not act as a hot point or hot bulb, and after the engine is warmed up, the heating element may be removed and the engine started again without it.

Ignition of the fuel when the engine is in operation is produced by combination of a combustion chamber of peculiar shape, arrangement of spray nozzles, and timing of fuel injection. As regards this latter, it is stated that the intake valve is closed by the valve spring, the piston in its turn compressing the air from the cylinder into the combustion chamber to a pressure of approximately 200 lb. per sq. in. Injection of the fuel starts near the end of the stroke and is completed before the piston has reached the end of its travel. The solid system of injection is used. (*Automotive Manufacturer*, vol. 62, no. 3, June 9, 1920, pp. 7-12, 6 figs., *d*)

MACHINE SHOP

Hints for Working Monel Metal

Working Monel Metal, Hugh R. Williams. Monel metal cuts like no other metal. In fact, so far as cleaving action of the cutting tool is concerned, it is more like brass than like steel. It is removed in ribbons and because of its toughness, high-speed-steel cutting tools with keen edge and decided rake have to be used.

For monel-metal cutting only the better grades of high-speed steel should be employed. As a general rule, monel metal can be machined dry, though cutting lubricants and cooling solutions may be necessary for fine work. Table 1 gives a list of such lubricants for monel metal.

Monel metal can be machined effectively at a wide range of cutting speeds from a slow speed of 8 ft. or 10 ft. per min. with a heavy cut and feed to as high as 250 ft. per min., with a light cut and feed, provided ample power is available. As a rule, on general work a speed of 50 ft. or 60 ft. per min.,

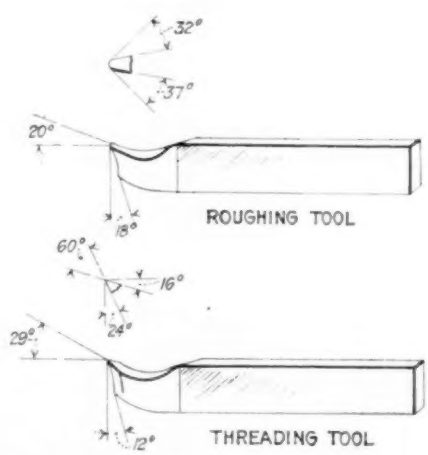


Fig. 8 Tools for Working Monel Metal

with a 1/8-in. cut and a 1-32-in. feed, will be found to be satisfactory, but if a high finish is desired the depth of the cut should be decreased and a higher cutting speed employed, care being taken to keep the tool sharp.

The following instructions are given for polishing and grinding monel metal:

Castings. (1) Use a solid stone, of which there are several grades and makes. The Norton Company's grade "Q," grain No. 20; and Carborundum Company's grade "G," grain No. 16, are very satisfactory. (2) A rag, wood, or canvas wheel coated with No. 40 emery. (3) A rag, wood, or canvas wheel coated with No. 120 emery. (4) A rag, wood, or canvas wheel coated with No. 120 emery and finished with an ordinary buff, using buffing compound.

Hot-rolled Rods. (1) A rag, wood, or canvas wheel coated with No. 90 emery. (2) A rag, wood, or canvas wheel coated

TABLE 1. CUTTING LUBRICANTS FOR MONEL METAL

Operation	Lubricant
Boring (fine)	Mineral lard oil, larcul, lard oil and 10 per cent turpentine
Cutting-off	Soluble oils, solul, borax, and aquadag
General	Mineral lard oil (light), larcul, solul, soluble oils exanol.
Milling	Soluble oils, solul, oakite.

with No. 120 emery. (3) A rag, wood, or canvas wheel coated with No. 120 emery and finished with an ordinary buff, using buffing compound.

Sheets. (1) A rag, wood, or canvas wheel coated with No. 90 emery. (2) A rag, wood, or canvas wheel coated with No. 120 emery. (3) A rag, wood, or canvas wheel coated with No. 120 emery and finished with an ordinary buff, using buffing compound.

The original article also discusses in detail the welding, annealing and pickling of monel metal. (*Mechanical World*, vol. 67, no. 1746, June 18, 1920, pp. 400-401, 3 figs., *p*).

MACHINE SHOP

Tests on the Behavior, Efficiency and Life of Hack Saws

HACK SAWS, THEIR SELECTION AND USE. The ability to cut in the shortest time is one of the important factors determining the value of a hack saw, but the rate at which the saw cuts may be made such as to become destructive. The endurance of the saw is also a factor.

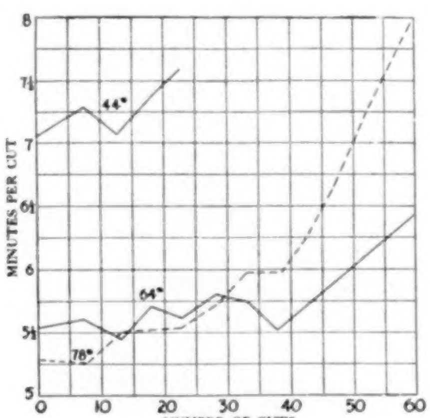


FIG. 9 EFFECT OF PRESSURE ON TIME PER CUT AND EFFICIENCY OF SAW

The gradual lowering of efficiency as the saw is used and the effect of successive increases in the pressure are displayed in Fig. 9. The curve for 44 lb. shows how rapidly the saw was running beyond the limit of efficiency, while that for 64 lb. makes clear how the tendency was immediately restrained by the application of more weight. This figure also illustrates the effect of weight or pressure on the rate of cutting and the efficient endurance of the saw, identical blades being used on the same material in this test and different weights employed, the starting weight remaining constant throughout the test in each case.

In the case of the 44-lb. weight, the weight used was below that recommended for the blade employed. The second solid line shows the improvement in performance of a similar saw using the proper weight of 64 lb., while the dotted line illustrates what happens when a slightly excessive pressure is employed. Insufficient weight resulted in an excessive time per cut and on the whole the chart would indicate that, first, it is better to exceed the proper weight a little at the outset than to use too little pressure, and second, no matter how nearly correct the weight is at the outset, after a certain number of cuts have been made the pressure must be increased, not only for the sake of reducing the time per cut to a point within the limits of efficiency, but also to prolong the life of the saw.

The effect of a slight excess in weight on the average time of cuts made before the blade is dulled is clearly shown by the two lower curves in Fig. 9. For the first fifteen cuts the advantage lies clearly with the heavier weight, but from that point on, it is apparent that the first saving in time was made at the expense of the general average for the entire series of cuts.

Another series of tests illustrated by curves in the original article indicates the destructive action of an excessive pressure. While the hack saw must be made to withstand a great amount of abuse, there are limits beyond which it will not go. Where a hack saw is forced to cut at a greatly excessive speed, the gain in time per cut may be offset by loss in saws, spoiled stock, etc. On the other hand, however, insufficient pressure affects the life of the saw almost as rapidly and in the same manner as when too much weight is used. In this case, moreover, the teeth of the blades are destroyed by slipping and sliding over the work rather than by cutting. It would appear,

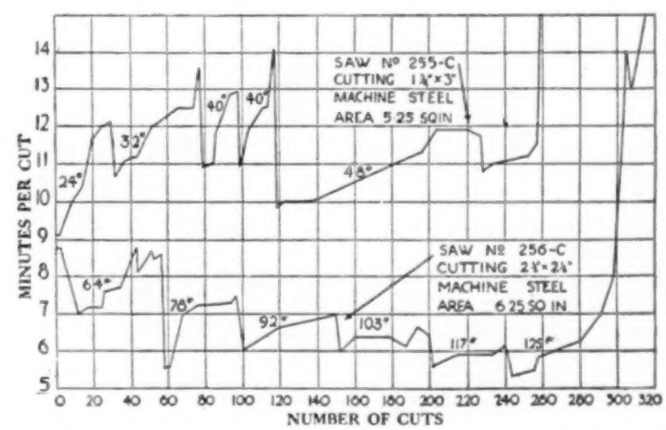


FIG. 10 EFFECT OF PROPER AND IMPROPER REGULATION OF WEIGHT ON CUTTING SPEED AND LIFE OF SAW

therefore, that using too little pressure is almost as inefficient and costly as using too much, and has not even the doubtful advantage of saving time at the expense of the blade and stock as is the case where too much pressure is employed.

Data are presented on the comparative advantage of flexible and all-hard blades. From this it would appear that the all-hard blades designed for use in machines require less time per cut than flexible blades, while the total number of cuts made by each blade is practically identical and the saws failed in almost the same manner. It would therefore appear that the use of flexible saws in power machines is attended by a loss of time in cutting without any corresponding gain in the life of the blade.

Data are also presented comparing the results of starting with an excessively light weight combined with proper subsequent regulation on one hand, and on the other hand with results obtained by using a slightly excessive weight to start with and then regulating it properly as the number of cuts progresses.

These results are presented graphically in Fig. 10 and from them it would appear that on the first blade (No. 255-C) an excessively light weight was used. The time per cut was excessive until about the thirtieth cut, when the weight was increased with a result in drop in time per cut from 30 min. 35 sec. to 10 min. 35 sec. The blade, however, was dulled so much by sliding over the work that it was not until the weight had been still more increased that the proper time per cut was reached.

In the second test (No. 256-C) a weight of 64 lb. was employed, whereas only 43 lb. is recommended. While overweighted at the start, the blade cut well within the limits of efficiency for nearly 40 cuts.

In presenting the data for these tests, the paper calls atten-

tion to the fact that the relative efficiencies of blades can be better determined by the number of square inches cut, rather than merely the number of cuts made. Thus in the above two tests, the first saw cut, before failing, 1365 sq. in. and the second saw 1742 sq. in.

Tests presented graphically in Fig. 11 are of considerable interest as they show the effect of the lubricant. Starrett No. 250 flexible blades were used and all were started under the same pressure of 24 lb. The line AB shows the performance of a saw run without lubricant at 65 strokes per min., an ex-

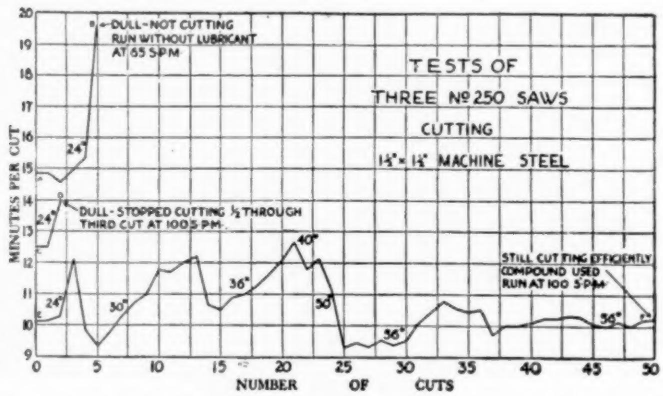


Fig. 11 Effect of Using Lubricant on Time per Cut and on Life of Saw

cess of 15 strokes over the recommended speed. This saw failed when partly through the fifth cut.

The saw of curve CD was run dry at 100 strokes per minute, or double the proper speed, and failed very rapidly. The saw EF was run with the lubricant compound at 100 strokes per minute, and completed 50 cuts. The test was discontinued before the saw failed.

The following formula is given for making the lubricant compound: To a quart of sal soda thoroughly dissolved in 10 gallons of cold water add 4 quarts of equal parts of mineral and lard oil, and mix thoroughly. The compound is ready for use 10 or 12 hours after it is made.

The original article discusses the question of cost per cut and gives several tables, among others being tables for combined cost per hour for saw, labor and overhead at different costs of labor and saw blades. The question of cornering work is also discussed in detail and various methods of proper and improper cornering are illustrated. (*Canadian Machinery*, vol. 24, no. 4, July 22, 1920, pp. 91-97, 19 figs., *peA*)

MARINE ENGINEERING

British Rivetless Ship

Electrically Welded Ship "Fullagar." Description of the electrically welded, motor-driven ship *Fullagar*.

This ship is a coaster 150 ft. long by 23 ft. 9 in. beam, and 11 ft. 6 in. deep to the main deck. It is an entirely welded ship and there is not a rivet in her from one end to the other. Of course, this may not prove to be absolutely the necessary way of construction, but it was a good way of demonstrating the suitability of electric welding for shipbuilding purposes, although it did not demonstrate that it is necessarily the cheapest way of construction.

The hull is constructed of steel of the usual ship qualities, tested in accordance with Lloyd's rules in the ordinary way.

As a working rule, it was arranged that as far as possible no overhead welding should be called for on the job. Complete elimination of such welding, however, was impossible, but in almost every case it was found that joints could be planned so that such overhead welding as was done should be of a light type and should be reinforced by heavy welds put on in a downward direction.

Illustrations are given of the various types of welds used. Of these, the system of "broken" welding is of particular interest. For joints not required to be watertight, the welding is put on in short lengths with unwelded spaces between instead of being continuous. The only reason for this is economy of labor and material. A sample of such continuous welding is shown at the connections between the main frames and the shell plates in Fig. 12A. Also, in Fig. 12B an arrangement is shown where the welds are placed alternately on either side of the frames.

In the welds shown in Fig. 12C (lower end of the main frames) the frame is welded all around to the plate. Service holes are also shown. These are, of course, employed in connection with erection, but in order to conserve the all-welded construction, they are not riveted after use, but are plugged and welded over.

The whole of the welding has been carried out by the quasi-arc

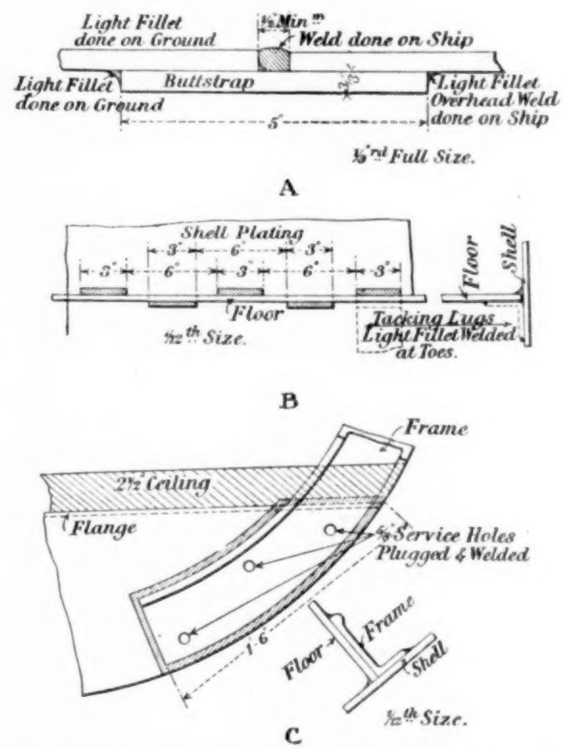


Fig. 12 Welds Used on the Electrically Driven Ship *Fullagar*

system, previously approved by the Lloyd's Register of Shipping, which latter has also embodied in the ordinary rules of the Society a set of rules for its application.

The body is fitted with a Cammellaird-Fullagar opposed-piston oil engine of about 540 b.h.p., working on a single screw. (*Engineering*, vol. 110, no. 2844, July 2, 1920, pp. 25-26, 14 figs., *dA*)

MECHANICS

The Strength of Cardan Shafts, A Johnson. A mathematical discussion of the forces acting on a Cardan shaft. In this connection attention is called to a paper by Thom in a Swiss engineering magazine abstracted in Mechanical Engineering, July 1920, pp. 409-410.

Besides the ordinary twisting moment, a Cardan shaft is subject to a bending moment due primarily to its own weight. It is in the position of a beam supported, but not fixed, at the ends, and uniformly loaded with w pounds per unit length.

The equation which defines the critical length of a shaft as given in reference books is:

$$2l = \pi \left(\frac{gEI}{wa^2}\right)^{\frac{1}{4}} \qquad [1]$$

where $2l$=whole length of shaft
g=acceleration due to gravity
E=Young's modulus

I = moment of inertia of section
w = weight of shaft per unit of length, pounds
a = angular velocity of shaft in radians per second.

This formula unfortunately lends itself to ambiguity owing to the selection of incompatible units or careless interpretation of symbols. It is true only when all the dimensions are in *feet*, and consequently when E is Young's modulus in pounds *per square foot*, or 144 times the ordinary tabular value of E in pounds per square inch. Similarly when all four dimensions are taken in inches, the most convenient unit, it is necessary to remember that g is not the abstract number 32.2, but represents a concrete quantity of *feet*, and therefore when 1 in. is the unit the formula for the limiting length of a shaft becomes:

$$2l = \pi\left(\frac{12gEI}{wa^2}\right)^{\frac{1}{4}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

where $2l$ = whole length of shaft, inches
g = 32.2
E = Young's modulus in pounds per square inch
I = moments of inertia of section
$= \pi D^4/64$ for a solid round shaft when D = diameter of shaft in inches
w = weight of shaft in pounds per inch length
a = angular velocity of shaft in radians per second.

The author derives the following equation for the greatest bending moment M:

$$M = \beta^2 (Q - 2N) EI$$
$$= \beta^2 \frac{12g}{2a^2}\left(\frac{1}{\cos\beta l} - \frac{2}{(e^{\beta l} + e^{-\beta l})}\right) EI \qquad \ldots\ldots\ldots\ldots [11]$$

where $\beta = \left(\frac{12gEI}{wa^2}\right)^{\frac{1}{4}}$ and Q and N are constants.

Now the bending moment $M = fz$, where f is the greatest stress per square inch of the material, and z is the strength modulus of the section, which for a solid round shaft of diameter D inches is $\pi D^3/32$.

Therefore we have from [11]:

$$f\frac{\pi D^3}{32} = \beta^2 \frac{12g}{2a^2}\left(\frac{1}{\cos\beta l} - \frac{2}{(e^{\beta l} + e^{-\beta l})}\right) E\frac{\pi D^4}{64}$$

or

$$f = DE\frac{\beta^2}{4}\frac{12g}{a^2}\left(\frac{1}{\cos\beta l} - \frac{2}{(e^{\beta l} + e^{-\beta l})}\right) \qquad \ldots\ldots\ldots [12]$$

where $\beta^2 = \sqrt{\frac{wa^2}{12gEI}}$ as before.

From these equations the author derives Equation [2] by noting that the bending moment and the stress per square inch become infinite when $\cos\beta l = 0$, that is, when $\beta l = \pi/2$.

Thus the author has found that in a shaft of which the limiting length calculated according to Equation [2] was 32 in., a length of 30 in. showed a stress due to bending of only 1400 lb. per sq. in. as calculated from Equation [12], which would indicate that the limiting length of a shaft may be approached closely without danger of stress.

The author believes that if the statements embodied in Equations [11] and [12] have any real physical basis, a shaft need not be in danger at a speed higher than the critical speed if it could be restrained from whirling until the critical speed were well past. (*The Automobile Engineer*, vol. 10, no. 140, July, 1920, pp. 266-267, *tm.*)

MOTOR-CAR ENGINEERING

Frameless Car. Description of a non-conventional design of a car recently patented by the Lancia Company. The body (Fig. 13) consists of a stamped sheet-steel shell and combines the function of a body with that of a frame. At the front of this shell is attached horizontally a form of stirrup, to which in turn is attached a semi-elliptic transverse spring, shackled at each end to the forks of a straight front axle.

Fore-and-aft location of the front axle relative to the body is obtained by the use of a radius rod on each side, running from the bottom of the axle back to the body. Suspension for the rear axle consists of long quarter-elliptic springs, the butt ends of which are attached to the body at a point where a channel rib forming part of the front-seat support crosses and stiffens the body.

An essential feature of this construction is the use of a channel-section rib or tunnel running longitudinally from the front

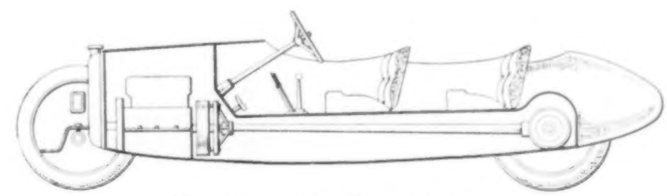


Fig. 13 Lancia Frameless Car

portion to the back and forming also a compartment open at the bottom in which the propeller shaft can move. Clearance for the rear axle is given by a similar tunnel running transversely across the back of the body. These channels may be made by stamping the sheet metal forming the lower portion of the shell to form a longitudinal member, thus improving the stiffness of the body without, to any extent, reducing the footroom capacity of the seating accommodation.

No information is given as to how accessibility to the engine is secured in this design. (*Autocar*, vol. 64, no. 1287, June 19, 1920, p. 1160, 2 figs. *d*).

POWER GENERATION

Emmet Mercury Boiler. The basic idea of the Emmet mercury boiler has been known for several years. It is to so use mercury as to increase the temperature range through which the engine operates. Mercury permits it to do so because of its higher boiling point as compared with water. On the other hand, however, if a boiler or turbine were to operate with mercury in the same manner as they are operated today with steam, the amount of mercury needed would be extremely large and there would be considerable danger of leaks, undesirable both because of the high cost of mercury and still more so because of the fact that mercury vapor is poisonous.

To avoid this, Mr. Emmet has designed a binary-vapor plant using mercury vapor and steam. The products of combustion from the furnace pass upward through part of the tubes which form the heating surface of the mercury boiler and then forward through tubes containing water. The mercury tubes are connected to the lower mercury chest and to the mercury header which takes the place of the steam drum in an ordinary boiler. Mercury vapor at about 10 lb. gage pressure is collected in the header and passes to the mercury turbine. Owing to the high density and low velocity of the mercury vapor this turbine may be a single-stage machine of reasonably low speed and may have short buckets. The wheel may be placed inside the mercury condenser for simplicity.

The mercury condenser is a vital part of the unit. It consists of a tank supporting another tank which may be called a steam drum. A number of straight tubes extend from the bottom of the steam drum into the condenser. The exhaust from the mercury turbine is condensed on the surface of these tubes and as the boiling point of the mercury at 28 in. vacuum is 455 deg. fahr., steam is generated inside the tubes. This steam is led to a superheater and finally to the place where it is to be used, while the steam condensate is returned to a condensed-steam receiver and from there through a feedwater heater to the steam boiler.

The mercury condensate is drained from the bottom of the mercury condenser to the lower mercury header and thence to the mercury boiler.

In order to utilize mercury economically and to use a minimum amount of it, a special type of boiler had to be designed. In this boiler flattened tubes are used. Leaks are said to be prevented by great care in the design and construction of the fittings and pipes leading to and from the mercury boiler.

The original article states that Mr. Emmet has claimed that by

the addition of this device to an assumed good modern power station with an increase of 15 per cent in the amount of fuel used, the same amount of steam can be supplied to the steam turbine as under present conditions, and the mercury turbine will generate power equal to about 66 per cent of the power generated by the steam turbine.

The experimental equipment was in operation for a short time last summer with a load of over 1000 kw. on the mercury turbine, and its operation showed that the economies predicted were fully realized.

In an editorial article in the August 3 issue of *Power* it is stated that there is a persistent rumor that an Emmet mercury-vapor plant is being built for the Hartford (Conn.) Electric Light Company. This would be of particular interest, as it was in the plant of this company that the first steam turbine of commercial size was installed for electric power generation. (*Power*, vol. 52, no. 5, Aug. 3, 1920, pp. 167-168 and 1 full-page colored diagram, *dA*)

Waste-Heat Boilers, D. S. Jacobus and Arthur D. Pratt, Members Am. Soc. M. E. In modern practice with waste-heat boilers no special effort is made to minimize the frictional resistance of the gases flowing through the boiler by providing a large flow space.

Nowadays, waste-heat boilers are provided having a high draft resistance and in which the baffling is so arranged as to give a relatively small area of flow space through the passes so as greatly to increase the velocity of the gases. On the other hand, a suction fan is used to overcome the higher draft losses due to the increase in velocity of the gases, and the heating surface of the boiler is arranged in series in such a manner that in connection with the added draft loss under the increased velocity, the desired draft will be available at the outlet of the furnace supplying the waste heat as well as the outlet of the boiler.

In waste-heat boilers the heat-transfer rate should be materially higher than in direct-fired boilers. In the latter a temperature is developed greatly in excess of the average waste-gas temperature and a considerable proportion of the total heat absorbed by a boiler is absorbed through direct radiation to the tubes which are exposed to the radiant heat of the furnace.

The absence of this important factor may be compensated in the waste-heat boiler by raising the gas velocity. In this connection it should be borne in mind that the heat-transfer rate is dependent upon the gas velocity and not upon the number of passes, except in so far as the number of passes affects the velocity.

The best arrangement to use in most cases is the three-pass, but the number of passes depends generally on several considerations discussed in detail in the original paper.

Economizers are frequently installed in connection with waste-heat boilers.

The authors recommend a combination in which a three-pass boiler is used. The gases pass from the boiler through the vertical rear circulating tubes directly into an economizer which is made up of horizontally inclined tubes extending transversely to the boiler setting. The gases pass downward over the economizer tubes while the water has an upward flow, the countercurrent being obtained between the water and the gases, and the water in the economizer flowing continuously upward so as to avoid any pockets should steam be formed in the economizer.

Single-pass waste-heat boilers without induced draft were among the earliest to be used and there still appears to be a considerable field for such boilers, even under modern conditions. They can, however, be successfully used only in connection with a furnace requiring a low draft. A single-pass boiler may be used to advantage where a low weight of gas is available and may be best to install in the case of an isolated plant where there is is outlet for the power developed expect for use in the plant. (*Proceedings of the Engineers' Society of Western Pennsylvania*, vol. 36, no. 4, pp. 221-234, and discussion pp. 235-242, *g*)

VARIA

War Experience with Merchant Ships, Prof. J. J. Welch. A paper discussing damage to vessels of various types caused by torpedoes or mines, and suggesting certain changes in design which might make the ship more fit to withstand external explosions.

As regards the nature and extent of damage caused by a torpedo or mine, attention is called to the fact that when a vessel is struck in way of a cargo hold, the hatches are usually blown off, which gives a certain relief of the pressure set up by the explosion. It would appear as probable that large hatchways afford an improved measure of protection to a ship.

The sizes of the holes made by torpedoes varied in the vessels which subsequently reached port from about 40 ft. by 23 ft. to 16 ft. by 14 ft. It would appear that a vessel should be reasonably safe against attack from a single torpedo if it were made capable of remaining afloat with any two holds open to the sea, while the minimum length of hold should not be less than, say, 40 to 45 ft., so as to avoid the possibility of two bulkheads being injured at the same time.

The first effect on a damaged ship was to produce a heel temporarily to the damaged side, due to the influx of water on that side, which heel was eliminated or reduced as the water became uniformly distributed across the ship. In some cases the loss of metacentric height, due to the loose water admitted to holds, was sufficient to render the ship initially unstable, and heeling resulted from this cause; such heeling being diminished, or the ship even regaining the upright, as the water in the hold reached the level of the water outside. This follows from the well-known fact that the loss of initial stability is generally greatest when the quantity of water admitted is relatively small. Treating the question as one of loss of buoyancy, with constant displacement, the position of C. G. of ship remains fixed throughout, while the variation in location of metacenter depends upon the rise of the center of buoyancy and the length of B. M. At an early stage of the inflow, the position of C. B. remains practically unaffected, while the diminution in the length of B. M. is given by $\mu i/V$ with the usual notation, μ being the fractional permeability of the damaged compartment. The value of i, the total amount of inertia of water plane area in damaged compartments, is more or less constant at all heights, and hence the loss of G. M. may be considerable in the early stages, and less important as the water rises in the compartment and so raises the position of the center of buoyancy of ship. For this reason it is more important to have watertight doors low down in the containing bulkheads of damaged compartment shut at the time of the casualty than similar doors at a higher level. The final result may be the same, but by confirming the longitudinal extent of the free water low down, the ship may continue upright, and if the ship has ultimately to be abandoned, the upright position will facilitate the getting away of the boats and so conduce to the saving of life.

An examination of the steamers torpedoed showed that very few capsized, but a fairly large number retained a list after damage. Some of these ships listed in a lightly laden condition due to the fact that many vessels of relatively fine form have only very moderate matecentric heights when lightly laden, so that the loss of stability due to the inflow of water might have been sufficient to give a negative G. M. with consequent heeling; in one case, indeed, the loss of stability due to this cause was so great as to result in the capsizing of the vessel. On the other hand, vessels in full form carrying their breadth well down often have very large matacentric heights when lightly laden and many such vessels in this condition have continued afloat upright with two or more large compartments flooded. (Paper read before the Institution of Naval Architects, July 6, 1920, abstracted through *Engineering*, vol. 110, no. 2845, July 9, 1920, pp. 37-40, 2 figs., *dg*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

United States Forest Products Laboratory Celebrates Its Decennial

EXTENSIVE conservation of our national wealth of wood through more efficient utilization was the keynote sounded throughout the Decennial Celebration at the Forest Products Laboratory at Madison, Wis., July 22 and 23. Over 200 visitors from all parts of the country were present, representing every line of wood-using industry, including 59 wood-using associations and companies, 18 lumber-manufacturing associations and companies, the deans of 12 forestry schools, the United States Forest Service, and other visitors and friends. They came to pay tribute to the laboratory's ten-year record of service to American industry.

The Forest Products Laboratory is a government institution of industrial research in wood and all wood products maintained by the United States Forest Service in coöperation with the University of Wisconsin. In this work 220 engineers, wood technologists, manufacturing specialists, and assistants are employed in developing new uses for wood and improving present manufacturing methods. Investigations and experiments are undertaken both independently and for individuals and companies on a coöperative basis.

The committee in charge of the celebration consisted of Governor Philipp of Wisconsin, honorary chairman; H. F. Weiss, Burgess Laboratories, Madison, and former director of the laboratory, chairman; C. P. Winslow, director, Forests Products Laboratory; H. J. Thorkelson, business manager, University of Wisconsin, and Don E. Mowry, general secretary, Madison Association of Commerce.

The opening session of all the celebration convened at ten o'clock on the morning of July 22. The program of addresses included Legislative Measures for Forest Conservation, by Governor Philipp; Translating Knowledge into Power, by President Birge of the University of Wisconsin; and The Forest Products Laboratory, by C. P. Winslow, present director of that institution.

After luncheon the program continued with inspection of the work and exhibits of the laboratory. Guides in charge of small parties showed the visitors the various lines of endeavor in which the laboratory is saving millions of dollars a year to the people of the country.

Nearly 500 prominent lumbermen, manufacturers, and users of forest products, and members of the Forest Products Laboratory, attended the banquet in the evening, at which Lieut.-Col. W. B. Greeley, Chief Forester of the United States, spoke on Forests and National Prosperity; and Mr. Max Mason, research specialist of the National Council of Defense, gave an illustrated talk explaining in detail the submarine detector which he perfected during the war and which was successfully used in European waters.

At the Friday morning session D. C. Everest, secretary and general manager, Marathon Paper Mills Company, spoke on Some Problems of the Pulp and Paper Industry; H. E. Howe, chairman, Research Extension Division, National Research Council, on America's Place in Industrial Research; and W. A. Gilchrist, representing the National Lumber Manufacturers' Association, on Some Problems of the Lumber Industry.

In the Forest Products Laboratory the Government has established an institution which is doing much direct good for all of the wood-using industries. Director Winslow in speaking of its purposes and work illustrated the manifold uses of wood in connection with the every-day life of the people. He brought out the great problems of conservation and utilization of forests, of cut lumber and of finished product. He stated that it was the broad purpose of the Forest Products Laboratory to aid the nation in solving these problems.

Mr. Winslow gave statistics showing by conservative estimate that the work of the Forest Products Laboratory effected an annual increase in production and decrease in waste aggregating $30,000,000. These figures, he said, should prove the value and importance of industrial research.

THE ST. LAWRENCE RIVER PROJECT

(Continued from page 512)

It would seem, therefore, that the minimum power that may be developed from the St. Lawrence and distributed through northern New York and northern New England would be about 830,000 hp. It is not unlikely, however, that in the final bargaining between the two countries regarding the whole matter the United States may assume some of the expense of the improvement below the international section of the river and in return receive more power, inasmuch as the demand is relatively greater in the United States.

In a preliminary way the Canadian Government recently estimated the cost of the St. Lawrence improvement for the international section (including preparation for power installation but not the machinery and equipment for power development and distribution) at $60,000,000 and for the all-Canadian section of the river $50,000,000, not to include power development. The total, $110,000,000, may upon more detailed examination prove to be too small and $200,000,000 may be necessary. Suppose that the United States pays one-half of the total, $100,000,000, and gets one-half of the 4,000,000 hp. No matter how low the rental price on this may be, great profits should be derived and in a few years the entire cost amortized. Then there is the more fundamental question of conservation. A horsepower-year has been reckoned as equivalent to a coal saving as high as 30 tons; however, the author considers this too much and assumes 20 tons instead. The total coal to be saved is a very important item, and if 40 million tons of fuel can be saved, the additional tonnage necessary to transport it from the coal fields to the territory where the electric power would be used will be saved with it. This element of saving is variously reckoned at from 10 to 25 per cent of the primary coal tonnage. Considered internationally the saving would be predicated on the full 4,000,000 hp. and might amount to 100 million tons a year.

Again, there is the question of man power. How many miners are required to mine 100 million tons of coal, and how many mine laborers and others are employed in and about the mines? How many railway employees would be necessary to transport the coal and to haul the empty cars back to the mines? How many firemen and engineers in steam-driven power plants would be saved for other productive effort? The problem has many ramifications, but from whatever angle it is considered, a possibility of saving is at once apparent. The improvement of the St. Lawrence river is amply justified, even if considered solely as a conservation measure. Indeed, a careful study of the problem will show that there is no excuse for the people to neglect the taking of adequate steps to develop this power.

Returning to the question of transportation, if the United States is to continue shipping abroad yearly 300 million bushels of grain produced in the Middle West, how much of the shipping cost can be saved? Mr. Julius Barnes, who has just been relieved of his duties as Chief of the U. S. Grain Corporation, states that it may safely be estimated at from 5 to 6 cents per bushel, which would be $15,000,000 to $18,000,000 per annum. There are also other goods to be shipped in and out. That the total saving would be enormous and sufficient to justify the expense is undoubted.

Consider also the effect on immigration. At the present time the United States and Canada are suffering from a lack of man power. At the present time immigrants, particularly from the northern countries—Holland, the Scandinavian countries, and the British Isles—are very desirable. The cost of coming to our shores is now several times what it used to be, and when they land at some Atlantic port they must either stay in the already congested areas there or pay a big charge for railroad transportation. Some of the northwestern states have a large percentage of Scandinavian-born people. Practically all of the Scandinavians who come to this country settle in Wisconsin, Minnesota, and the Dakotas. Others will no doubt do the same. If they could come directly to some one of our Great Lakes ports, consider how much easier it would be for them and how much less expensive, not to mention the benefits of such immigration to the Central West.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

Engineering Experiment Station, Iowa State College

THE Engineering Experiment Station of the Iowa State College was established in 1904 and since that time it has issued 57 bulletins. Twenty-one of these have been devoted to sewage, drainage, drainage tiles and sewer pipes, nine to bricks and roads, nine to the use of Iowa coal for power and house heating and to mechanical-engineering subjects. In addition to these there have been bulletins on the holding power of nails, cement, concrete, electric power on the farm, topographical surveys, lighting, structural work and paints. For further information address Dean Anson Marston, Director, Engineering Experiment Station, Ames, Iowa.

Coöperation

The Portland Cement Association and the Lewis Institute of Chicago are coöperating in their structural materials research laboratory. A number of bulletins have been issued as a result of this work. The Advisory Committee from Lewis Institute includes Profs. Duff A. Abrams and Philip B. Woodworth, while the Portland Cement Association is represented by Chairman F. W. Kelley of Albany, N. Y., and Ernest Ashton, of Allentown, Pa.

Research Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulæ or curves where such may be readily given and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Cement and Other Building Materials A5-20 Modulus of Elasticity of Concrete. Bulletin No. 5 of the Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill., by Stanton Walker, is on modulus of elasticity of concrete, with an appendix applying the results obtained to flexure of reinforced-concrete beams. Results show that the stress-deformation curve is of the form $S = Kd^n$ and the modulus of elasticity varies with the stress in a manner represented by the equation $E = CS^m$, where S = unit stress, d = unit deformation and E = modulus of elasticity.

There is no true elastic limit since the stress-deformation diagram is a curved line. There is a point where the equation above for stress and deformation no longer holds and this corresponds to the yield point used by some writers. This occurs at from 50 to 90 per cent. of the ultimate strength.

Four moduli of elasticity are noted: The initial tangent called E_i; the tangent modulus at from 5 to 50 per cent of the compressive strength called E_t; the secant modulus from 5 to 50 per cent of the compressive sthength E_s; and the cord modulus E_d, which is determined by taking points on each side of the point at which the tangent modulus is found. The tangent modulus and the cord modulus are approximately the same. The initial modulus is given by the equation $E_i = 33{,}000\,S^m$, where $m = 0.625$. The modulus at 25 per cent of the compressive strength is given by $E_{t25} = 66{,}000\,S^m$, where $m = 0.5$. The modulus of elasticity and strength increases as the aggregate becomes coarser, as the quantity of cement in the batch increases, as the age of the concrete increases and as the time of the mixing increases. The quantity of water has a great effect on the modulus and the strength. These decrease as the water is increased. There is no marked difference between concretes made of high-grade pebbles, crushed limestone, crushed granite or blast-furnace slag. Address Prof. Duff A. Abrams, Lewis Institute, Chicago, Ill.

Cement and Other Building Materials A6-20 Effect of Fineness of Cement. The effect of fineness of cement is discussed by Professor Duff A. Abrams in Bulletin No. 4 of the Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill. The bulletin contains 81 pages and is the result of tests on 6125 concrete cylinders, 4935 cement-mortar cylinders and 4065 briquets, as well as over 5000 other tests. Some of the conclusions reached are as follows:

1. There is no necessary relation between the strength of concrete and fineness of cements if different cements are considered.
2. In general the strength of concrete increases with the fineness.
4. Fine grinding of cement is more effective in increasing the strength of lean mixtures than rich ones.
5. Fine grinding is more effective on short-time tests.
12. The fineness of cement has no appreciable effect on the yield or density of concrete.
14. The unit weight of cement decreases with fineness.
23. Tension tests of briquets do not give a correct measure of the relative merits of different cements as determined by compression tests of mortar and concrete.

Address Prof. Duff A. Abrams, Lewis Institute, Chicago, Ill.

Cement and Other Building Materials A7-20 Storage of Cement. Bulletin No. 6 of the Structural Materials Laboratory of Lewis Institute, Chicago, Ill., on the Effect of Storage of Cement, by Prof. Duff A. Abrams, was issued in June. The report includes compression tests on about 1000 6-in. by 12-in. concrete cylinders and 1000 2-in. by 4-in. cylinders of 1:3 standard sand mortars and about 500 miscellaneous tests. Tests have been under way for 3½ years. The following conclusions are noted:

1. Indications of the 1:5 concrete cylinders and 1:3 Ottawa sand-mortar cylinders are comparable.
2. Compression tests showed a deterioration in strength with storage of cement for all samples. The deterioration was greatest in the samples stored in open shed in yard, sample stored in basement of building showed less deterioration and those in laboratory showed still less.
3. After three months' storage in shed in yard cement had 80 per cent. of its original strength; after six months, 71 per cent.; after one year 61 per cent. and after two years 40 per cent. The deterioration was probably greater in these tests on from 8 to 12 sacks than it would be found in a larger amount of cement stored under similar conditions.
5. For periods up to 1½ years there is no marked difference in the quality of cement stored in cloth and paper bags.
6. Only a slight advantage was found from protection of cement in cloth sacks which were covered by a thin layer of portland cement or hydrated lime.
8. Storage of cement prolongs the time of initial and final setting.
10. The normal consistency was slightly effected by storage.
12. The deterioration of cement in storage appears to be due to absorption of atmospheric moisture causing partial hydration which exhibits itself in reducing the strength of the concrete and prolonging the time of setting.

Address Prof. Duff A. Abrams, Lewis Institute, Chicago, Ill.

Cement and Other Building Materials A8-20 Strength of Drain Tiles. Bulletin No. 57 of the Engineering Experiment Station of Iowa State College, on supporting strength of drain title and sewer pipe under different pipe-laying conditions, by W. H. Schlick, was issued in April 1920. The bulletin contains 68 pages divided into six sections as follows:

1. The problem of design of drains and pipe sewers with safe supporting strengths.
2. General description of investigation.
3. Earth and pipe-laying methods.
4. Concrete-cradle pipe-laying methods for firm soils.
5. Concrete-cradle pipe-laying methods for yielding soils.
6. Pipe-laying methods with concrete cradles whose values are independent of the nature of the soil.

Tests were made on 24-in. sewer pipes, 24-in. clay drain pipes, 18-in. sewer pipes and drain pipe and 12-in. sewer pipe. The tests for the ordinary earth beddings showed the ordinary supporting strength of pipes to be slightly exceeded, while special laboratory tests showed that the effect of eliminating hub holes in trenches decreased the strength of the pipe from 15 to 27 per cent. With concrete beddings the strength of the pipe was increased from 70 to 100 per cent. in firm soils and from 32 to 68 per cent. in yielding soils. In general the concrete

bedding will increase the strength of the tile about 100 per cent.

Address Engineering Experiment Station Ames, Iowa, Anson Marston, Director.

Cement and Other Building Materials A9-20 Concrete and Cement. The bulletins issued by the Structural Materials Research Laboratory of the Lewis Institute carried out through the coöperation of the Lewis Institute and the Portland Cement Association are as follows:

- Circular 1 Colorimetric Test for Organic Impurities in Sands, by Duff A. Abrams and Oscar E. Harder (1917). Out of print.
- Bulletin 1 Design of Concrete Mixtures, by Duff A. Abrams (1919).
- Bulletin 2 Effect of Curing Condition on the Wear and Strength of Concrete, by Duff A. Abrams (1919).
- Bulletin 3 Effect of Vibration, Jigging and Pressure on Fresh Concrete, by Duff A. Abrams (1919).
- Bulletin 4 Effect of Fineness of Cement, by Duff A. Abrams (1919).
- Bulletin 5 Modulus of Elasticity of Concrete, by Stanton Walker (1920).
- Bulletin 6 Effect of Storage of Cement, by Duff A. Abrams (1920).

Address Prof. Duff A. Abrams, Lewis Institute, Chicago, Ill.

Fuels, Gas, Tar and Coke A8-20 Heating Values. The heating value of a gas containing sufficient hydrocarbons to burn yellow may be obtained by burning the gas in a burner so constructed that the gas and air thoroughly mix and determining the relative amount of air to gas at the instant at which the yellow tip disappears. From a great number of experiments at different pressures and with gas of different heating values it was found that the air-gas ratio was always the same at the instant at which the yellow tip disappeared. The fact that the amount required for complete combustion should be a measure of the heating value has been known for some time. These experiments, however, were conducted to prove the fact and to develop a simple form of burner and apparatus by which the mixture of air and gas could be readily determined at the disappearance of the yellow tip. The mixture is expelled by rising water from an apparatus which gives a constantly changing air-gas ratio and then water. The water is stopped when the flame passes through the yellow tip and the stationary level is a measure of the heating value of the gas. The laboratory has devised the formula B.t.u. $= 158R + 276.5$, where R is the value of the air-gas ratio and the heating value is the heating value of 1 cu. ft. The slope of the line (158) is approximately equal to the gram molecular heat of combustion of the radical CH_2. The constant of the equation 276.5 is the heating value per cu. ft. of C_2 burned to CO_2 on the assumption that C_2 is a gas.

Address Edward J. Brady, Physical Laboratory United Gas Improvement Company, 3101 Passayunk Ave., Philadelphia, Pa.

Metallurgy and Metallography A12-20 Arsenic in Steel. The effect of arsenic in steel has been determined at the naval gun factory by P. E. McKinney, chemist and metallurgist.

"In view of the fact that the question has frequently arisen as to the effect of varying percentage of arsenic in steel," says Mr. McKinney, "it was deemed expedient to make a few experiments in connection with the regular manufacturing operation on the effect of this element.

"Two series of experiments were made, the first consisting of a comparison between a plain converter steel and steel from the same heat to which had been added 0.1 per cent arsenic. The second series was identical except that an addition of 0.5 per cent arsenic was made.

"After adding the final addition to a regular converter heat, a 3¾-in. diam. by 32-in. long split ingot mold was top-poured from a bull ladle for this plain test. Then about 3 in. of steel was poured into a hot bull ladle, of about 100 lb. capacity, to cover bottom, the metallic arsenic mixed with several times its weight of thermit and wrapped in paper, was thrown in ladle, the ladle was then filled with steel, mixed and top-poured into a similar mold. This constituted the arsenic test ingot. Both series were handled in the same way.

"The ingots were stripped the following morning, sent to forge shop, heated and forged longitudinally from bottom end to ¾-in. square, and cut into 6-in. lengths—a convenient size for test bars. They were not soaked or annealed before forging but both series worked excellently while being forged. All of the 6-in. lengths were annealed at 1400 deg. fahr., and then heat-treated as shown in Table 1. The ingots whose heat numbers are followed by the letter A are those to which arsenic was added:

TABLE 1. EFFECT OF VARYING THE PERCENTAGE OF ARSENIC IN STEEL

FIRST SERIES

Chemical analysis	Heat No.	C	Si	P	S	Mn	As	Remarks
	C-1082	0.18	0.26	0.025	0.021	0.60	0.031	No arsenic added
	C-1082A	0.10	0.24	0.023	0.030	0.62	0.089	1% arsenic added

Annealed (deg. fahr.)	Oil-quenched (deg. fahr.)	Drawn (deg. fahr.)	Heat No.	P. E. L.	T. S.	Elong. %	Red. %	Rupture	Bend.	Fracture
1400	....	....	C-1082	48300	75300	32.50	62.30	138900	....	Perfect cup
1400	....	....	C-1082A	43200	72200	33.50	62.79	125520	....	½ cup
1400	1450	500	C-1082	48400	92900	26.00	57.22	162100	180°	$\frac{8}{10}$ cup
1400	1450	500	C-1082A	53500	88100	28.50	60.56	164800	180°	Perfect cup
1400	1450	1000	C-1082	58600	88400	28.25	60.56	157800	....	¾ cup
1400	1450	1000	C-1082A	53400	85300	31.25	64.42	179200	....	[illegible] cup
1400	1450	1200	C-1082	53500	84500	32.25	65.43	161100	....	$\frac{95}{100}$ cup
1400	1450	1200	C-1082A	53500	80000	32.00	67.74	162500	....	¾ cup

SECOND SERIES

Chemical analysis	Heat No.	C	Si	P	S	Mn	As.	Remarks
	C-1123	0.13	0.25	0.019	0.048	0.57	0.065	No arsenic added
	C-1123A	0.12	0.33	0.018	0.045	0.57	0.310	0.5% arsenic added cold

Annealed (deg. fahr.)	Oil-quenched (deg. fahr.)	Drawn (deg. fahr.)	Heat No.	P. E. L.	T. S.	Elong. %	Red. %	Rupture	Bend	Fracture
1400	....	....	C-1123	35500	67700	32.00	68.00	147300	....	¾ cup
1400	....	....	C-1123A	39600	67800	3[illegible].50	67.50	139000	....	½ cup
1400	1450	500	C-1123	45800	75100	31.00	62.20	143800	180°	[illegible] cup
1400	1450	500	C-1123A	45800	77600	25.00	58.50	141300	180°	½ cup
1400	1450	1000	C-1123	45800	72100	30.15	65.40	141500	....	[illegible] cup
1400	1450	1000	C-1123A	49600	74000	33.50	64.60	143700	....	[illegible] cup
1400	1450	1200	C-1123	42700	69300	32.00	70.40	157300	....	[illegible] cup
1400	1450	1200	C-1123A	48800	73460	33.50	69.50	153600	....	¾ cup

"The results of these tests show practically no difference between the steel containing no arsenic and that to which arsenic has been added, and if anything the result of test shows slight superiority in favor of the steel containing arsenic. While these tests were made on small ingots and the test piece received considerable longitudinal forging work, the results of these preliminary tests would not indicate that arsenic has the detrimental effect to steel attributed to it by some authorities.

"There is no noticeable difference in the properties of steel containing arsenic as compared with that to which no arsenic additions were made. In the pouring or forging the steel acted normal in every respect."

While it is evident from these experiments that 0.3 per cent of arsenic is not injurious, as far as static testing can disclose, the fact must not be lost sight of that it is extremely hard to get rid of arsenic after it is once present in steel, and if the steel is used for scrap purposes after its usefulness has ceased, there is a constant automatic augmentation of the arsenic content which will in time get beyond the limits desired. It would also be interesting to note the effect of arsenic upon shock-resisting qualities of the steel which is of major importance where ordnance work is concerned.

The Gun Factory hopes to have an impact machine installed in the very near future, and further experiments along this line will be carried out.

Address Bureau of Ordnance, U. S. Navy, Washington, D. C.

Metallurgy and Metallography A13-20 Tests for Defects in Spring Steel. Numerous breakages were obtained in ¾-in. round silico-manganese spring steel during a 24-hr. solid clamping test of spring steel. Deep seams were found in torsion tests. After various heat treatments seams developed. To guard against the receipt of such bars a comparison test has been devised in which a piece, the length of which is 1½ times the thickness of the bar, is compressed to a length equal to the thickness of the bar. Internal seams open widely under such a test. Metallurgical and Testing Division, Naval Gun Factory, Washington, D. C. Address Chief of Bureau.

Metallurgy and Metallography A14-20 Alloy Steels. An investigation including an extensive micrographic examination of specimens indicates that zirconium, titanium and aluminum are not truly alloying elements but act merely as scavengers. When not eliminated in slag they are present in the steel as inclusions. In small amounts they may help produce soundness but otherwise they can not do much good and may even be detrimental. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

B—Research in Progress.

The purpose of this section of Engineering Research is to bring together those who are working on the same problems for coöperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Metallurgy and Metallography B8-20 Bearing Metal. Compressive tests at 25, 50, 75 and 100 deg. cent. have been made on five different compositions of babbitt metal, four of which correspond to proposed specifications of the S. A. E. The best pouring temperature and the effect of aging as well as the micromechanism of failure will be investigated. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Textile Manufacture and Clothing B2-20 Cotton Research Company. The work of the Cotton Research Company is divided between researches in the mill and in the laboratory. The mill researches are as follows:

Relative value of speeds of heaters and blows per inch in picking processes;

The best speed for doffers and drafts to use in carding different cottons;

Comparisons of yarns made from various varieties of cotton with and without combing process;

Comparison of spinning with self-weighted and lever-weighted rolls;

Size mixtures most suitable for various types of warp yarns;

Connection between atmospheric conditions and relative weights throughout manufacture of yarns.

The laboratory researches are devoted to the following:

Analysis of cotton fibers and raw cotton throughout manufacture;

Value of fabrics from yarns containing various amounts of twists per inch;

Effects of humidity on sizing and breaking of fabrics.

Address Cotton Research Company, 1020 Washington St., Boston, Mass. E. D. Walen, Manager.

C—Research Problems

The purpose of this section of Engineering Research is to bring together persons who desire cooperation in research work or to bring together those who have problems and no equipment with those who are equipped to carry on research. It is hoped that those desiring cooperation or aid will state problems for publication in this section.

Internal-Combustion Motors C1-20 International Harvester Co. The problems covered by Laboratory No. 5 of the International Harvester Company devoted to gas-power engineering is concerned with two sets of problems:

A Development of present manufactured products.

B Development for future market.

Under A there are two main divisions:

I Materials of Construction.

II Working Processes.

Under Materials of Construction the following sub-division occurs:

1 Characteristics of present products
2 Changes to eliminate failure in service
3 Changes for improvement in operation
4 Changes to facilitate production or manufacture
5 Development to meet future conditions.

Under Working Processes the following subdivisions are found:

1 Determining the performance, characteristics and laws of the present working process.
2 Changes to meet present difficulties or failures in service.
3 Development to secure improved operation, production or economy.
4 Development to meet future conditions.

Machine Design C1-20 Ball Bearings. Recent investigations on the arrangement, strength and serviceable features of ball bearings for flat footstep bearings is desired by W. S. Aldrich, American Bridge Company, Gary, Ind.

D—Research Equipment

The purpose of this section of Engineering Research is to give in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories so that persons desiring special investigations may know where such work can be done.

International Harvester Company D1-20 Gas-Power Engineering Laboratory. Laboratory for the development of research work on trucks, tractors, stationary engines of high and low compression, lighting outfits, various accessories and other products. Road tests are also operated by the Company.

The laboratory is situated in a building with a sawtooth roof, equipped with traveling crane, piping for water, gasoline, kerosene and compressed air and wired for electric power. Fuel is supplied to engines from individual tanks on scales. Exhaust is cared for by overhead exhaust line connected to fan blower. Ventilator stacks with openings at floor level are equipped with an exhaust fan. A motor-generator set supplies direct current for battery charging, field and armature current for d.c. motors and generators and field current for the Sprague dynamometer.

Equipment

100-hp., 1050 to 3500 r.p.m. Sprague dynamometer fitted with electric contactors for fuel weighing and recording revolutions.

Electrically indicating tachometer.

Electrically controlled revolution counter.

Hand tachometers.

Revolution counters and stop watches.

Toledo scales, electrically controlled for time element and hydrometers are used in fuel measurement.

Venturi meters recording water meters, sharp-edged orifices and pressure gages are used for water measurement.

Bristol recording thermometers, nitrogen-filled mercury thermometers.

Leeds & Northrup recording and indicating potientiometer.

Hoskins pyrometer and thermocouples are used for heat measurement.

Crosby indicators, diaphram indicators of the Bureau of Standards and manograph are used for power measurement.

An air-equalizing tank with sharp-edged orifice and Ellison gage.

Venturi tubes, pitot tubes and anamometers, displacement gas meters, recording and indicating barometers.

Thermometers and psychometers are used for air measurement.

Five test stands with direct-current generators are used for absorbing power.

Five stands with prony brakes are used for testing engines. Three of these are equipped with balances and supported brakes. Several other test stands are used for small and large engine work.

A brake band testing outfit is arranged to measure belt tension, slippage and durability as well as the coefficient of friction and endurance of brake and clutch linings. An apparatus for determining the endurance of fan belts under various tensions and temperatures is installed in this section of the laboratory.

The friction losses in gear-transmission lubricants are determined by a motor driving a generator through gear transmission.

The laboratory is planning apparatus to determine the tractor drawbar pull, tractive effort, torque reaction about driving axle, power delivered by belt pulley and general performance data from tractors.

The laboratory is equipped to determine the heat dissipation of radiators at various rates of air and water flow.

The laboratory is equipped for the development work on high-compression engines. A 1-hp. Hvid thermoil engine and a 10-hp. high-compression engine are installed.

The capacity, endurance and performance characteristics of generators and storage batteries or other electrical apparatus may be determined by the equipment in the laboratory. Apparatus for determining the characteristics of steam and steam engines are found in the laboratory.

Calorimeters for determining the heating values of solid and

liquid fuels are found in the Chemical-Physical laboratory of the Company.

The laboratory is equipped for complete and thorough investigations of automotive apparatus, the characteristics of engine auxiliaries and development work on specific problems.

Research Personnel:

Chief Engineer, Steam Research Engineer, several development engineers and office force of computers, a test-force foreman, chief tester, testers and mechanics.

Address International Harvester Company, 606 South Michigan Ave., Chicago, Ill. E. A. Johnston, Manager, Experimental Department.

E—RESEARCH PERSONNEL

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

F—BIBLIOGRAPHIES

The purpose of this section of Engineering Research is to inform the profession and especially the members of the A. S. M. E., of bibliographies which have been prepared. These bibliographies have been prepared at the request of members, and where the bibliography is not extensive, this is done at the expense of the Society. For bibliographies of a general nature the Society is prepared to make extensive bibliographies at the expense of the Society on the approval of the Research Committee. After these bibliographies are prepared they are loaned to the person requesting them for a period of one month. Additional copies are prepared which are available for periods of two weeks to members of the A. S. M. E. or to others recommended by members of the A. S. M. E. These bibliographies are on file in the offices of the Society and are to be loaned on request. The bibliographies are prepared by the staff of the Library of the United Engineering Society which is probably the largest Engineering Library in this country.

Mechanics F1-20 Impact and Alternating Stress Tests. Impact. A bibliography of 10 pages. Address A. S. M. E., 29 West 39th St., New York.

Molecular Physics F1-20 Capillarity and Surface Tension. A bibliography of 1 page. Address A. S. M. E., 29 West 39th St., New York.

Properties of Engineering Materials F1-20 Impact and Alternating Stress Tests. Impact. A bibliography of 10 pages. Address A. S. M. E., 29 West 39th St., New York.

WORK OF THE A. S. M. E. BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 269 and 307 to 312 inclusive, as formulated at the meeting of June 24, 1920, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

CASE No. 269 (Reopened)

Inquiry: If, under the provision made in Par. 212 of the Boiler Code, advantage is taken of the opportunity to increase the pitch of the staying for a cylindrical furnace, is it to be assumed that a portion of the increased load on the staybolt is to be supported by the resistance of the outer cylindrical shell to collapse, or must the staybolt be designed to carry the full load upon the stayed area of the furnace sheet?

Reply: The special provision made in Par. 212*c* for increased pitch is made possible by the additional strength afforded by the convexing of the plate. It is permissible under this rule to increase the spacing of the staybolts to p_1 in the formula, whereas the required cross-sectional area of the staybolts should be based on p.

CASE No. 307

Inquiry: Is it permissible to so locate the supporting lugs on h. r. t. boilers where more than four lugs are required and under Par. 323 of the Code, must be set in pairs, that those in each pair come close together, or must the horizontal distance between the center lines of rivets attaching the adjacent lugs to the shell be at least equal to the vertical spacing of rivets that is required for lug attachments in Par. 323, as shown in Fig. 8?

Reply: There is no requirement in the Code specifying the distance apart of the lugs forming pairs as required by the last sentence of Par. 323. It is the opinion of the Committee, however, that in locating lugs in pairs on the shells of h. r. t. boilers, it will be in conformity with the spirit of the second sentence of Par. 323 if the lugs of the pair are so spaced that the horizontal distance between the centers of the rivets which come nearest the adjacent edges of the lugs is at least 6 in., and not more than 12 in.

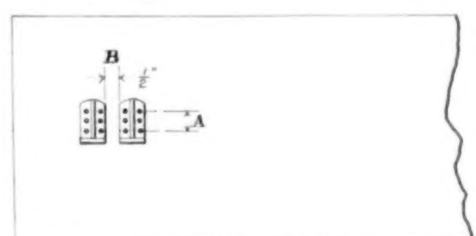


FIG. 8 SPACING OF SUPPORTING LUGS IN PAIRS ON H. R. T. BOILERS

CASE No. 308

Inquiry: Under what rules in the Boiler Code should the top head of a vertical submerged-tube type of fire-tube boiler, such as shown in Fig. 9, be calculated to determine whether or not it requires bracing?

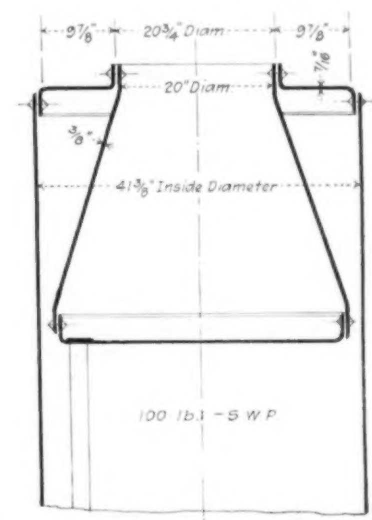


FIG. 9 DESIGN OF TOP HEAD OF VERTICAL SUBMERGED-TUBE TYPE OF FIRE-TUBE BOILER

Reply: There is no rule in the Code specifically applying to such construction. However, in Par. 216, an allowance is

made for surfaces located between tubes and shells. It is the opinion of the Committee that it would be entirely safe to permit similar allowances in this case, that is, the distance between supported points could be made 3 in. greater than the permissible spacing of staybolts for the corresponding plate thickness and pressure given in Table 4.

Case No. 309

Inquiry: Is it necessary to furnish test reports of the steel used in the tubes or flues of special type boilers which are formed of 18 in. lap welded steel tubing, 15 ft. long, where the wall thickness is $\frac{1}{2}$ in. and the weld meets the requirements of Par. 186?

Reply: It is the opinion of the Committee that the material used in the manufacture of lap-welded low-carbon steel tubing should meet the stipulations prescribed in Pars. 23 to 39 inclusive of the Code, which will make it necessary to furnish mill test reports of the material.

Case No. 310
(In the hands of the Committee)

Case No. 311

Inquiry: Is it necessary under Par. 188 of the Boiler Code to use butt-stray joints in the construction of very small drums, say, 10 or 12 in. in diameter, for pressures exceeding 100 lb. per sq. in? Such construction does not appear to be practical for such small drums and neck pieces sometimes used to connect drums or shells.

Reply: Lap-riveted construction is prohibited by the Code Rules, but it is the opinion of the Committee that this should cause no hardship as lap-welded or seamless pipe or tubes could be used, provided such tubes or pipes are constructed from material which in its initial form of plate or skelp conforms to one or the other of the specifications for open hearth steel given in the Boiler Code. No test would be required on the completed tube. (See Case No. 255).

Case No. 312

Inquiry: Is it necessary in the construction of small Star-type water-tube boilers for steam heating which are to carry more than 15 lb. pressure at times, to drill the inside and outside ends of staybolts? It is believed that it was the intent of the Committee to cover in this requirement the water legs at front and back ends which are considered as headers.

Reply: If the grate area is more than 15 sq. ft., the staybolts are less than 8 in. in length, and the pressure exceeds 15 lb., it will be necessary to drill the staybolts in order to comply with the Code requirements.

Conference Committee on Welding

The Boiler Code Committee takes pleasure in announcing that the American Welding Society has appointed a Committee to confer with the Sub-Committee of the Boiler Code Committee on Welding. The above is the result of an invitation extended by the Council of the A.S.M.E. at the request of the Boiler Code Committee. It is the desire of the Boiler Code Committee that the Committee of the American Welding Society shall coöperate with the Sub-Committee of the Boiler Code Committee in discussing the rules now in the Code and in proposing any revisions or new rules that may be embodied in the Code at the next revision period. The personnel of the Committee appointed by the American Welding Society is as follows:

A. S. Kinsey, *Chairman*, Stevens Institute of Technology, Hoboken, N. J.

C. A. Adams, National Research Council and Director of American Bureau of Welding, 29 West 39th St., New York, N. Y.

A. M. Candy, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Alexander Churchward, Wilson Welder & Metals Co., 253 36th St., Brooklyn, N. Y.

J. H. Deppeler, Metal & Thermit Corporation, 92 Bishop St., Jersey City, N. J.

R. E. Kinkead, Lincoln Electric Co., Cleveland, Ohio.

Victor Mauck, John Wood Mfg. Co., Conshohocken, Pa.

Stuart Plumley, Davis-Bournonville Co., Jersey City, N. J.

H. S. Smith, Prest-O-Lite Company, 30 East 42nd St., New York, N. Y.

R. E. Wagner, General Electric Co., Pittsburgh, Pa.

CORRESPONDENCE

Contributions to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this Journal, brief articles of current interest to mechanical engineers, or suggestions from members of The American Society of Mechanical Engineers as to a better conduct of A. S. M. E. affairs.

Federation an Opportunity for Local Societies

To the Editor:

The engineering profession of the country has been groping for many years after a suitable means of impressing its personality upon the public quite aside from the effort to secure betterment of individual conditions which has led to the remarkable development of the American Association of Engineers. The means sought for is at last at hand in the organization created on June 3 and 4 at Washington.

Every task accomplished is a source of satisfaction to those who participate in the performance, and so every society represented at the Washington conference has felt a thrill of pride at having been a part of the first movement offering a chance and a definite program for united service. Those societies whc were so unfortunate as not to be represented, as the facts become known to them, will begin to wonder why they were so indifferent. This is particularly true of the local society which finds in its local affairs only intermittent opportunities to expend its energies. Though local matters are the first that should receive engineers' attention, they are the soonest settled, while as the broader fields of service are approached the necessity for longer and more persistent effort rapidly develops. The opportunity afforded by the new organization to every local society to make its voice heard and take a part in the great affairs of the nation will certainly stimulate activity and interest in their members.

The effect of the organization on the national societies will be probably less apparent than on the smaller associations. They have long imagined that they were performing a great work and they will view the new organization as more or less of a side issue. Through it they will be able to exert a more effective influence on national and state questions, but the reaction will be of less importance than in the case of local and state organizations. Those technical matters in which the national societies are now coöperating seem unlikely to be affected, as the energies of the new organization will be absorbed in the solution of broader problems.

When it comes to such questions as a National Department of Public Works, the attitude of government toward the transportation industries of the country, the safe-guarding of national resources, and the protection and development of the

laboring class, the new organization affords the long-looked-for opportunity for that group of our citizens best qualified by education and experience, to place before the public and the legislators its recommendations and its criticisms.

GARDNER S. WILLIAMS.

Ann Arbor, Mich.

Federation Dues and Local Societies

TO THE EDITOR:

We all recognize that The Federated American Engineering Societies should do a great deal to stimulate the professional spirit of the engineer, as it will emphasize his relations to the public and to national affairs. However, it is even more important for the engineer that he take an interest in state and local affairs of an engineering nature. This can only be done if the idea of the Federation is carried down into the smaller units so that in every locality sections of the national societies and other engineering organizations are affiliated together and these affiliations are also carried out for the various states. This aspect is of course recognized in the constitution of The Federated American Engineering Societies, but I feel that active steps should be taken to further it at the very beginning of the organization.

The only difficulty for the average local society in coming into the Federation is the question of expense. Where a society has been very active in increasing its membership and has kept its dues at a low figure, say, $5.00, so as to reach the largest number, membership in the Federation will take 20 per cent of its annual budget. Furthermore, where the society is largely made up of members of national societies, some objection may be made to an increase in dues on the ground that payment has already been made through the national organizations. On the other hand, it is extremely important that as far as possible these local societies should become members of the Federation. It seems to me, therefore, that before these societies are asked to definitely decide the question of joining the Federation, a careful estimate should be made of the activities and expected expenditures and also the anticipated revenue of that organization. The possibilities of increased activities or of smaller payments should also be carefully pointed out. The possession of this information will help materially in the discussion of the finance committees and councils of local societies.

I hope that it will be possible to get practically every engineering organization of the country into The Federated American Engineering Societies.

JAMES A. HALL.

Providence, R. I.

A Criticism of the New Federation

TO THE EDITOR:

The constitution of The Federated American Engineering Societies makes two distinct and notable contributions to the progressive upbuilding of engineering as a profession, first through the avowal that the prime object of the organization is "to further the public welfare," and again in its stand "for principle of publicity and open meetings." This latter provision sounds a new note in quasi-public organizations.

But elsewhere in this constitution and by-laws one fails to discern any desire to get away from the traditional type of organization which has heretofore trammelled American engineering bodies especially in their work for the public.

Of vastly greater importance, however, than any possible defects in the type of organization adopted is the complete failure to recognize the necessity for enlisting the interest—aye, the enthusiasm—of the rank and file of the profession if we are to accomplish even a tithe of the task which the times demand of us.

In bringing about a union of all the engineering societies in the United States we are seeking fundamentally to effect three things:

1 The solidarity of the profession
2 To have our group thus unified, accept its public responsibilities, and
3 Gradually to develop and then to use the collective initiative thus created for the accomplishment of great public purposes.

The engineers of the United States today number at least 100,000—possibly 200,000. Within a decade or two it is not impossible that this may be increased to 500,000. Anything short of an effort to bring every one of these engineers individually into the fray by giving them a direct vote and otherwise, would be in the first place to go counter to every modern tendency in democratic theory, but of even greater immediate importance, it would deprive the new Federation of the most obvious means of educating and gradually enthusing the rank and file. This is just the kind of opportunity which was missed in the failure to provide that the members of the American Engineering Council should be elected by the votes of the members of constituent organizations rather than by the boards of these organizations.

In fact, the whole conception of the new Federation as expressed in its scheme of organization appears to be short-sighted almost to the point of insuring failure. This is not so much because it creates a typical super-organization but rather in its failure to recognize that power of the kind that makes for righteousness and the public welfare is grounded in the activities and devotion of the whole body—whatever that body may be, a ball team, a technical organization or the whole people. The effort in creating the Federation seems to have been to provide a board which could speak for the engineering profession rather than so to integrate the whole profession that when it speaks it will

1 Have something to say, and
2 In saying it carry reasonable conviction.

Still we must hope that this last effort at unity in the profession has something real to contribute, for deep in our hearts we engineers have a mighty purpose to fulfill—a purpose which cannot and will not long be thwarted and which only needs organization to make it effective.

MORRIS LLEWELLYN COOKE.

Philadelphia, Pa.

Determination of Fiber Stress Caused by Force Fits

TO THE EDITOR:

Having read with interest Mr. Wm. W. Gaylord's communication on the Strength of Thick Hollow Cylinders in MECHANICAL ENGINEERING for April, I am led to submit the two accompanying alignment charts which I have recently constructed for the determination of stress in thick hollow cylinders as applied to force fits. These charts are based on Birnie's formula for thick hollow cylinders, adapted to the case where the external pressure is zero—given in Fig. 2—in which

f_t = maximum fiber stress
e = allowance, or difference between inside diameter of hub and diameter of shaft
E_s = modulus of elasticity of shaft
E_h = modulus of elasticity of hub
R_s = radius of shaft
R_h = outside radius of hub.
$A = f(R_s, R_h)$

Fig. 1 has been constructed to obtain the value of A in the formula and Fig. 2 to obtain the value of f_t, A having been previously determined. Their use can best be explained by the solution of a definite problem.

Assume a steel shaft $2\frac{1}{2}$ in. in diameter ($R_s = 1\frac{1}{4}$ in.) to be forced into a cast-iron hub $5\frac{1}{2}$ in. outside diameter ($R_h = 2\frac{3}{4}$ in.) with an allowance (e) of 0.0025 in. Assume also that $E_s = 30,000,000$ for steel and $E_h = 28,000,000$ for cast iron.

Solution:

1 Lay a straight edge across the two points $R_s = 1\frac{1}{4}$ in. and $R_h = 2\frac{3}{4}$ in. of Fig. 1 and read $A = 1.854$ on the A-scale.

2 Obtain point u by laying a straight edge across the two points $A = 1.854$ and $E_h = 28{,}000{,}000$ on Fig. 2 and noting where it intersects the vertical ungraduated scale.

3 Connect points $e = 0.0025$ in. and $R_s = 1\frac{1}{4}$ in. by the line st.

4 Draw through point u a line uv parallel to st and read on the horizontal scale $f_t = 21{,}000$ lb. per sq. in. An algebraic solution of the two equations gives $A = 1.8542$ and $f_t = 20{,}970$ lb. per sq. in.

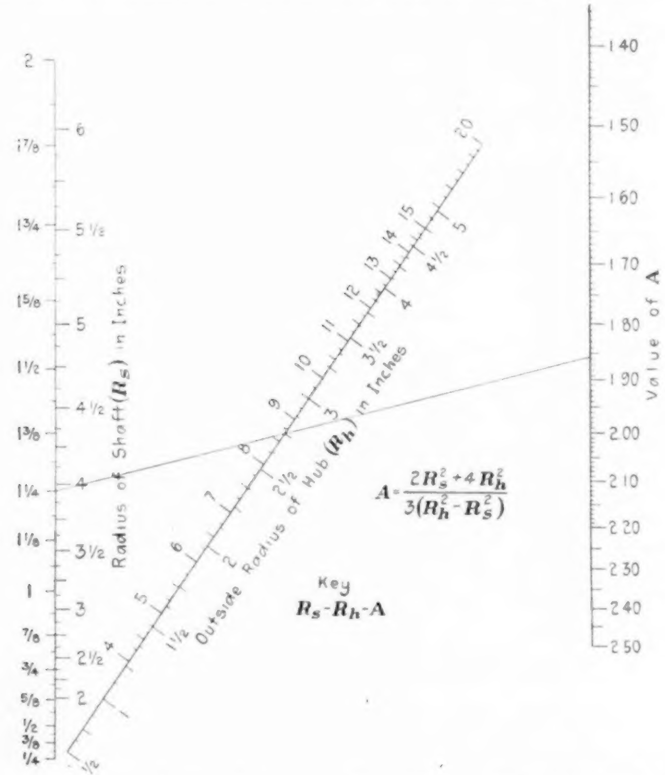


FIG. 1 FIBER STRESS CAUSED BY FORCE FITS. CHART FOR DETERMINING VALUE OF A IN BIRNIE'S FORMULA (SEE FIG. 2)

It will be noticed in Fig. 1 that for small values of R_s and R_h (below $R_s = 2$ in. and $R_h = 5$ in.) the points determining the straight line are very close together, and therefore the position of the line cannot be accurately determined. To obtain more accurate values of A in this region, a second scale has been added to the R_s- and R_h- axes. The outside graduations of these axes are for values of R_s from $\frac{1}{4}$ in. to 2 in. and R_h from $\frac{1}{2}$ in. to 5 in., while the inside range is for R_s from 2 in. to 6 in. and R_h from 4 in. to 20 in. In either case the straight line cuts the value of A on the right-hand scale.

It will also be noticed that in Fig. 2 the f_t- and R_s- scales have been so constructed that they are the same length and their graduations of the same length. If, then, these two scales be interchanged, which simply means interchanging the numerical values, the scales being identical, a chart will be obtained for intersecting index lines instead of parallel index lines. The secondary values on these two scales are for that purpose. The solution of the problem for intersecting lines is shown by the dotted lines and is obtained as follows:

1 In Fig. 2 draw line qur as before.

2 Connect points $e = 0.0025$ in. and $R_s = 1\frac{1}{4}$ in., R_s now being on the horizontal scale (line sw).

3 Draw a straight line through the intersection (y) of the line sw and fixed diagonal DB, and point u and at x read $f_t = 21{,}000$ lb. per sq. in. on the secondary values of vertical scale BC.

The use of intersecting index lines has certain advantages and disadvantages, as has also the use of parallel index lines. The chart of Fig. 2 has the advantage of using either or both together, taking the mean value of the two results. The original pencil-line charts give very accurate results, but their accuracy, of course, decreases through reproduction on a smaller scale.

The A-scale of Fig. 2 need not have been graduated below $A = 1.333$, for A can never be less than that value for positive values of R_h and R_s. The scales may also be extended to any desired limits.

It will be noticed that a chart of this type has one very great advantage over that of the ordinary logarithmic chart, in that the scales are all natural scales, i.e., not logarithmic, and therefore the graduations do not close up and become very small at one end. For example, a fiber stress of 29,300 lb. per sq. in. is just as easy to read from the chart as one of 11,300 lb., and if the scale were continued to 100,000 lb. it would still be just as easy to read, which would not be true of a logarithmic scale.

S. R. CUMMINGS.

Cambridge, Mass.

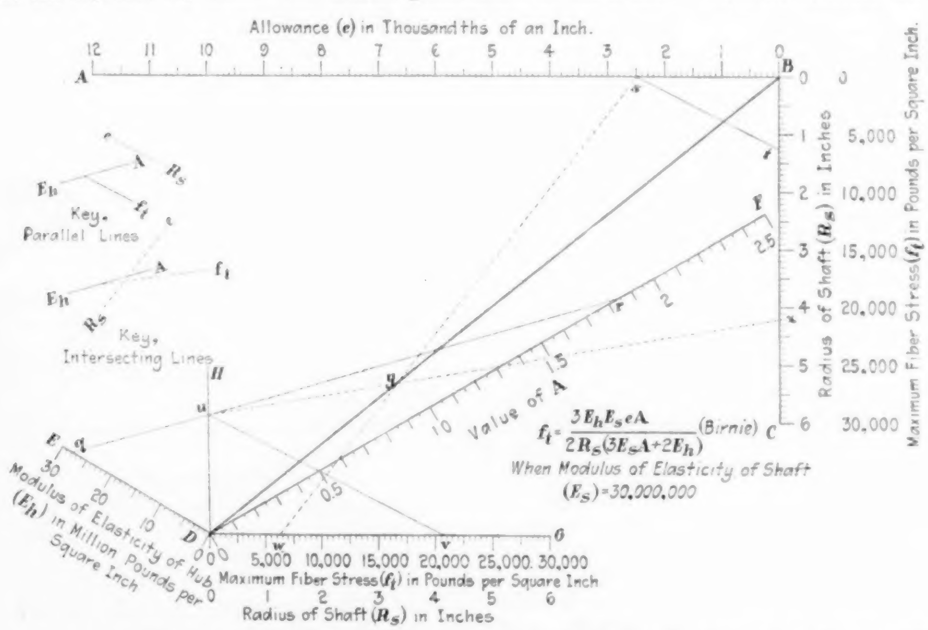


FIG. 2 CHART FOR DETERMINING MAXIMUM FIBER STRESS (f_t) CAUSED BY FORCE FITS

Load-Speed Capacities of Radial Ball Bearings

TO THE EDITOR:

The purpose of this communication is to arouse interest in a subject, often incorrectly treated, with a view of pointing out a correct solution. Ball bearings are in such general use and under such varied conditions that the engineer must have an accurate formula for calculating their strength.

There are at present two widely used formulæ for figuring the load-speed characteristics of radial or annular ball bearings. One is the Hess-Bright or D.W.F. formula—

$$W = knd^2$$

In which W=load in lb.

n=number of balls

d=diameter of balls in eighths of an inch

k=a constant varying with the condition and type of bearing, as also with the material and speed.

The second formula is that worked out by Professor Goodman—

$$W = knd^2/(RD+Cd)$$

In which W=load in lb.

n=number of balls

D=diameter of outer ring race in inches

d=ball diameter in inches

R=r.p.m.

K and C= constants having the values given below:

	C	k
Thrust bearings, flat races	200	500,000
Thrust bearings, grooved races	200	1,000,000 to 1,250,000
Radial bearings, flat races	2000	1,000,000
Radial bearings, grooved races	2000	2,000,000 to 2,500,000

As correctly stated by the authors of the Hess-Bright formula, the capacity of a bearing increases in direct proportion to the number of balls and the square of the ball diameter. The capacity decreases with the speed and varies with the type and material of the bearing. All of the variables last mentioned have been combined by some method in the constant k. From the writer's experience it would seem that a value of k must be worked out for every speed. This makes it a somewhat overworked constant and harder to assign a value to it than to figure the load-speed characteristics on a more rational basis.

Let us look at the Goodman formula with these points in view. We find that the load increases with the number of balls,

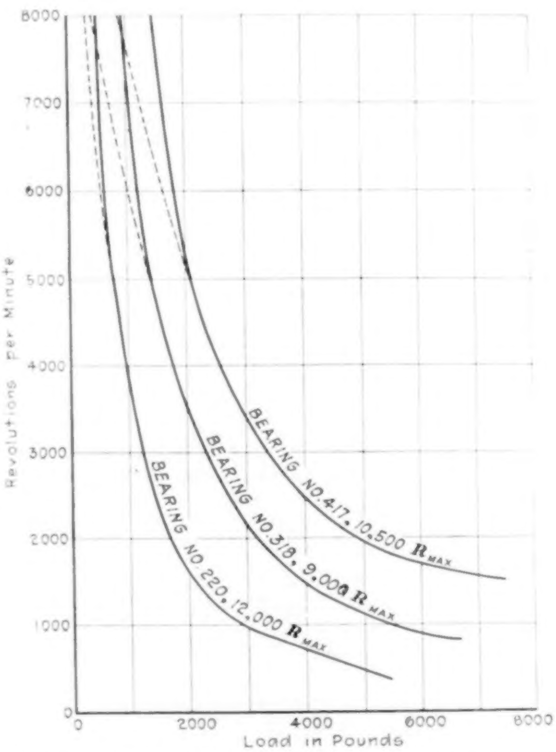


FIG. 3 VARIATION OF LOAD COMPOSITION OF REPRESENTATIVE BALL BEARINGS WITH SPEED IN R. P. M.

and, since d^2 is expressed in the numerator and d in the denominator, with the square of the ball diameter. The correctness of these facts is agreed to by all ball-bearing formulæ. We also find that the capacity decreases with the speed, which is quite obviously true. It also decreases with an increase in the diameter of the outer ring race, or in other words the diameter of the enclosing circle around the balls. We will see the logic of this assumption if we consider two bearings identical in number and size of balls but one having an outer ring race of greater diameter than the other. If the balls are evenly spaced there will be a greater length of arc between balls in the larger bearing than in the small one, and this naturally gives rise to a greater chance for deflection in the outer ring. We have left two constants which vary as shown in the table only for certain specific conditions, a value therefore being easily given them.

It appears from the foregoing that the Goodman formula is by far the more logical. There is, however, one consideration that this formula, and in fact all formulæ, neglects, namely, the maximum speed at which a bearing may be run. As shown in Fig. 3, which graph was obtained by plotting the Goodman formula for a few representative bearings, the curves reach zero load or their maximum speed at infinity. The curves shown by solid lines are the values given by Goodman and the additional dotted lines are a modification of this formula which will be described.

A formula has been derived by the writer for the maximum safe speed of a bearing under no load. This has been worked out from the standpoint of centrifugal force and a large factor of safety is used. It reduces to—

$$R_{max.} = K\sqrt{1/(D-d)}$$

In which R_{max} = maximum safe speed under no load
D = diameter of outer ring race in inches
d = ball diameter in inches
K = a constant to which a value of 25,000 has been assigned.

This value is correct for radial bearings having raceways of a radius = 0.54 of the ball diameter, made of alloy steel hardened clear through, and of the best accuracy known to the art.

To use this formula the values given by the Goodman formula are plotted. The maximum speed is figured from the above formula and plotted on the coördinate of zero load. Through this point a line is drawn tangent to the curve previously plotted. The result obtained is shown in the graph. This results, for large bearings, in a considerable reduction in the load-carrying capacity at the higher speeds.

The writer is indebted to Mr. Harry R. Reynolds for assistance in the preparation of this communication.

R. W. SELLEW.

New Britain, Conn.

Why Not a Tool-Drafting Standard?

TO THE EDITOR:

Many of our members who have been connected with the metal-manufacturing industry for many years can remember when tool drafting consisted mostly of verbal information, with perhaps a rough sketch of what was desired. This has been supplanted by more modern methods and the writer believes that tool designing and tool drafting have reached a stage today worthy of a consideration of some sort of codified standardization.

During 18 years of experience as tool maker and tool designer the writer has had the opportunity to observe many different uses of lines, letters, figures and symbols to express an idea, the majority of which failed to give a complete conception of the tools wanted. Mechanical engineers and chief draftsmen who in times of stress have had recourse to outside engineering firms to design and draw up the tooling of a new product, will vouch for the time lost in attempting to adapt drawings made by these outside firms to the system in vogue in their own drafting department. Such difficulties could be overcome if there was available some standard according to which the work might be done.

The writer suggests, therefore, that the newly created machine-shop section of the Society investigate the possibilities of an A. S. M. E. tool-drafting code whereby the best methods of expressing an idea by means of lines, letters, figures, and symbols would form some sort of universal language, the economical value of which would soon be felt.

FRED C. FRIEDLI.

Elmira, N. Y.

New York State Legislature Passes Bill for Licensing Engineers

The bill licensing engineers in the State of New York, adopted by the legislature in April 1920, became a law on May 14, 1920, when it was signed by Governor Smith. The bill is based upon Engineering Council's recommended uniform registration law, with certain modifications and changes conforming to the provisions of e isting law, a bill requiring the licensing of architects already having been enacted. A discussion of the bill as recommended by Engineering Council may be found on pages 77 and 78 of the January, 1920 issue of MECHANICAL ENGINEERING.

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A Plea for the Development of Our Water Powers

W. M. White

The people, of a right, should look to the engineer to point the way in the utilization of nature's forces which will result in the greatest relief from human toil, as they have looked in the past to the medical profession for relief from human ills. The people's faith in the good to come from the engineer's work is well expressed in the generous support given the Engineering Educational Institutions.

There has been installed recently at Niagara Falls a combined hydro-electric unit of 40,000 horsepower capacity. The operation of this unit requires two men per shift. It has been calculated that to produce the same amount of power by small isolated steam plants, as would be the case were the water power not developed, there would be required over 800 men to mine, hoist, break, screen, load, transport by railroad, unload, store, rehandle, and fire under boilers the coal necessary to develop by steam an equal amount of power. The operation of this one unit conserves not only one train load of coal per day, but also conserves the man power which would be required to produce it. This striking example shows the great amount of man power which can be conserved for other fields of endeavor by developing our water powers.

May it not be that the shortage of labor to accomplish the tasks before us today has been brought about by the failure to follow that path in the development of our natural resources which leads to the minimum of human toil?

Some time ago a member of the British Parliament pointed out in open meeting that the American workman has twice the horsepower per man behind him that the British workman has, and gave this as the reason for the ability of the manufacturers in the United States to pay to labor wages twice that paid in England and yet compete successfully in the World's markets in manufactured products. We have the power behind the workman, but the major portion of it is steam power, and we are paying a dear price for that power in men absorbed.

The economic advantage which the United States has heretofore enjoyed by reason of adequate power is being sought by other nations. For example, Japan only recently began the development of her water powers, but has already developed one and a half million of her total eight million water horsepower.

Failure to develop our water horsepowers has been seriously retarded due to a wrong conception of conservation, as manifestly there can be no true conservation as long as the power in the rivers is running to waste.

The shortage of labor which has increased the price of coal and the shortage of fuel oil, forces to our attention the necessity for the development of a large amount of our water powers during the next decade.

Laws have just been enacted governing the development of water power on Government Lands which will greatly influence hydro-electric development, particularly in the Western States. It seems a fitting task of the engineer to urge and aid the development of our water powers under the new law.

There has been developed in the United States today approximately nine million horsepower from water power, and there is yet available for development by this same means over fifty million horsepower; the development of which would save the labor of one million men.

When the war came on we were lamentably short in certain chemicals, chemical compounds and alloys. That small portion of our water powers which had been developed proved a great asset in our national crisis. That great portion of our resources in water power which was yet undeveloped was of no value in meeting the great emergency. The Government took control of the developed powers and directed their energy to war work solely. Water power centers became great producing communities in all things chemical. The energies of the great developed water powers were let loose in electric furnaces, and in electrolytic cells for making good the shortage in chemicals, chemical compounds, and alloys, but even this was not sufficient to meet the emergency. Huge steam plants were hurriedly constructed to supply additional power for this purpose, but this great construction work required labor not only for the construction, but for the operation of such plants which required enormous quantities of coal, thus absorbing man power at a time when every potential fighting unit should have been available for the front.

The development of our fifty million water horsepower now running to waste would mean not only a tremendous economic advantage to the people but a potential asset which might prove of incalculable value in case of war requiring the concentration of the man force of the nation for other than domestic uses.

Early development of the water powers would be the greatest move which could be made in the direction of true conservation.

Milwaukee, Wis. Wm. Monroe White.

The Important Water Power Problem

A study of the severe transportation problem has resulted in offering as a solution, vitally interesting to the engineer, the elimination of coal movements by developing the power at the mines, and uniting in one big system the power lines of the large industrial centers. Of equal interest in this problem, and of great value in the conservation of our fuel resources, is the problem of hydraulic power development.

In our desire to bring this problem home to the mechanical engineers of the country, several pages in the Survey of Engineering Progress in this issue are given to a digest of notable engineering articles covering the development of hydraulic machinery. Our signed editorial this month also bears on this problem, pointing out a conservation in man power that may be gained by greater utilization of water power.

The use of our hydraulic resources is a nation-wide question which commends itself to mechanical engineers, whether closely associated with its development or not.

The Raising of Engineering Limits

Throughout the entire field of engineering there has recently been apparent a tendency to raise the limits of working far beyond what was considered either safe or commercially practicable only a few years ago.

In the General Electric design of a super-power station, described in the August issue of MECHANICAL ENGINEERING, it is proposed to use a steam pressure of 350 lb. and superheat of 350 deg. fahr., the implication being that pipe, valves and fittings can now be commercially produced that will not be excessive in price and yet will safely stand these high mechanical and thermal stresses. In fact, 350 lb. pressure and 350 deg. fahr. superheat are by no means the limiting values under consideration, for 600 lb. pressure has been seriously mentioned as a possibility of the near future, if not a commercial value for use today.

In the field of refrigeration we have very nearly reached the limit of possibility, as Prof. Kammerlingh-Onnes in his work has come within 3 or 4 deg. of the absolute zero of temperature. It is true that such an excessively low temperature has not as yet been applied in commercial work, but only for the reason that thus far no process has been devised where it could be used commercially.

In the field of pressures other than steam, the limits have also been raised materially. Only a few years ago engineers spoke with somewhat bated breath of pressures of 200 atmospheres used in the various Linde processes for the separation of gases. Today commercial applications are being made of pressures at least five times as high, and pressures of 1200 and 1500 atmospheres are seriously under consideration.

The ability to raise the commercially reliable engineering limits of pressure, temperature, compression, etc., is undoubtedly due primarily to two causes. In the first place, our knowledge of the behavior of materials and our ability to produce materials of uniform quality have increased tremendously. Only fifteen years ago a tensile strength of 150,000 lb. per sq. in. was considered to be about the limit of strength of commercial metals, while 250,000 lb. does not represent the possibility of some of the special alloys of today. Moreover, with our present methods of testing materials and of producing alloys, and especially with our present methods of heat-treating them, it is possible to insure that a metal part will stand up under given enormous stress where there could be no such certainty only a few years ago.

In the second place, the improvement in our methods of machining has had a powerful influence in the same direction. In this connection an interesting illustration may be cited from the field of internal-combustion engineering. The Doxford oil engine uses a system of solid injection which is effected by means of a plunger pump exerting a pressure of 6000 lb. per sq. in. The remarkable part about this pump, however, is that it uses no packing. It appears, therefore, that it has become possible to produce a plunger and cylinder with such an accurate fit that a pressure of several tons to the square inch may be generated. It is easy to see what a substantial advance this represents in the precision of machine-shop processes.

This advance, in turn, has become possible through the improvement in the machine tools themselves, and especially through the fact that they are not only built better and of better materials, but are far more massive and rigid than they used to be a few years ago.

In the 50's of the last century, when the scientific world was still being taught the full realization of the principle of the conservation of energy, a favorite illustration used to be the lighting of a match. It was said that the world represented such a closely balanced unit that the release of the potential heat-energy content in the match was immediately reflected throughout the universe. The burning of the match raised the temperature of the surrounding atmosphere that produced a flow of air upwards which resulted in a tiny wind, etc.

Practically the same close co-working of phenomena is to be observed in engineering. The improvement of materials, tools and methods of machining makes possible the use of temperatures, pressures and compressions greater than any that have been used before. This, in its turn, calls attention to the economies and possibilities of the higher limits and calls for new efforts to improve still further the materials, processes, and machinery of production.

As a matter of fact, some very remarkable results in machining to close limits have been attained in the production of gages, as, for example, the Johanssen and Hoke precision gages. A remarkable part of this work is the ability of the gage makers to produce surfaces of such flatness that when two blocks are put together they adhere to each other with great force.

The production of such surfaces today is of value mainly in such a limited field as gage manufacture, but it would not be at all surprising, as stated by Mr. Johanssen, if a step further in the same direction would bring about a rather revolutionary process of joining metals. Gage blocks are already machined with such precision that when the surfaces of two such blocks are put together it takes a force of hundreds of pounds to tear them apart. One step further and it might become possible to produce blocks with two such perfect surfaces that when brought together they would exert upon each other their full molecular attraction, and, to all practical purposes, become one. In other words, welding by heat, which is nothing but bringing two metals to a state in which molecular attraction becomes possible, might be replaced by machining the two parts to a condition where the same result would be brought about.

Such an accomplishment admittedly would be difficult and probably impossible under our present knowledge. It is mentioned, however, as an illustration of the great new fields that loom ahead of the modern engineer and that have been brought within the range of possibility by the extension of our knowledge of producing and handling engineering materials.

Observations on the Work of the National Public Works Department Association[1]

The technical men who started the public works movement ought to know the accomplishments to date so that they may plan wisely for the future. This is a period of recess in legislative matters and we are given an opportunity to derive lessons from the events of the past. The National Public Works Department Association therefore submits this review with confidence that the supporters of the movement will have no reason to regret their participation therein.

Like all other movements of this kind, there are stages in which there is much visible progress and others in which development can be discerned only by those in intimate touch. We are now in one of the latter stages in which the principal effort is the preparation for achievement at the fall session of Congress. There could be no final success without these interim developments for they are as necessary to the final enactment of the measure by Congress as is the President's approval of the finished document following its passage.

We have won decisively in the first phase of this campaign, which is the establishment of the underlying principle. If every indication can be believed a Department of Public Works will be created. The leaders of Congress are in agreement on the principle and some of them are working on its details during the present legislative recess. The candidates for president and vice-president in both great parties have signified their approval and in this they are in step with the great leaders of thought and action the country over.

The second phase of the campaign, which consists of securing the right kind of a department of public works, will be more laborious than the first. It involves the minute consideration of

[1] The National Public Works Department Association is a league composed of individuals, associations and of national, state and local societies, having an aggregate membership of over 100,000 business men, engineers, architects, constructors, manufacturers, chemists, geologists and economists. Its purpose is to organize under one department the many and varied public works functions of the Federal Government. M. O. Leighton is chairman of the Association, and C. T. Chenery, secretary. The Association's headquarters are in the McLachlen Bldg., 10th and G St., Washington, D. C.

details, the sifting of evidence and the presentation of the results in convincing form. The supporters of this movement should not make the mistake of believing that the campaign is over merely because the principle has been accepted. It is obvious that the wrong kind of a Department of Public Works will be as bad if not worse than the present organization of governmental functions.

The most troublesome as well as the most inexcusable setback has been the failure of the movement in the referendum of the United States Chamber of Commerce. This was plainly due, first to the lack of adequate publicity, and second, to the inaction of the local engineering bodies which were depended upon to take care of the issue in their own local commercial organizations. Our finances would not permit us to handle the first, but we had every good reason to expect diligence on the part of "our own crowd" in the second. Evidence is constantly being accumulated that the important commercial bodies which voted adversely on that referendum did so in ignorance of the character, intent, and purport of the movement.

The principles underlying the public works movement—economy and efficiency and businesslike conduct of the Government's affairs—are not confined to the public works functions. The need is apparent in every line of Government functions. The Republican Party, for example, has adopted the principle as one of the planks in its platform. Reorganization of all departmental functions is as certain and steadfast a part of the Congressional legislative program as any other feature now before the public. It has been remarked in places that the public works department advocates may have done their job too well and have put forward so logical and persuasive a set of facts and principles that they must perforce be applied to the entire government structure with the possibility that the creation of the public works department may be delayed pending reform of all government functions. We are assured, however, that there will be no danger of such a result if the technical men of the country faithfully continue their activities on behalf of a public works department.

One of the most persuasive arguments against a proposal to delay the public works feature pending the announcement of a general reorganization bill is that previous efforts toward general reorganization have failed, first, because of the size and complexity of the job and, second, because it encountered so many points of opposition in the Federal bureaus. It is the opinion of such leaders in Congress as Senators Smoot of Utah and McCormick of Illinois, of Speaker Gillett of the House and of Representatives Madden of Illinois and Reavis of Nebraska that success will depend on the selection of one set of functions and the logical adjustment of them so that the underlying principle may be established in statutory form. It is agreed that the first and most logical set of functions is that which comprises the nation's public works.

From the present until the convening of Congress on the first Tuesday of December next, the engineers, architects, and technical men of other branches throughout the country have a rare opportunity to further this movement, because Congress is in recess and the representatives are at home. If each man who is convinced of the necessity for this reform would embrace this opportunity to instruct his representative in Congress and to enlist his active coöperation in the furtherance of this legislation, progress at the next session of Congress would be rapid and certain. For the present, members of Congress are almost out of reach of the Association's officers. The field of intensive effort has shifted "back home" where the technical men of the country may render "first aid."

Washington, D. C. M. O. Leighton.

Report on Industrial Conference Available

The American Society of Mechanical Engineers has on file at headquarters a limited number of copies of the Report of the Industrial Conference called by the President on December 1, 1919. The Society will be glad to furnish copies to those interested.

Charles Whiting Baker Retires from Journalism to Enter New Field

Charles Whiting Baker, Mem.Am.Soc.M.E., formerly editor-in-chief of *Engineering News* and later consulting editor of *Engineering News-Record*, announces his retirement from engineering journalism, in which he has so long been identified, to become managing director of a new service for the engineering and technical industries. Realizing the difficulty often experienced in bringing together those who have engineering properties to sell, and possible purchasers who have had experience in the fields of these industries and are qualified to manage them, Mr. Baker is to establish an engineering business exchange where owners and qualified customers may conveniently meet.

Mr. Baker has been connected with engineering journalism for thirty-four years, during twenty-two of which he was editor-in-chief of *Engineering News*. Readers of this publication and of *Engineering News-Record* are quite familiar with the illuminating quality of his writings and the breadth of view so often expressed in his editorial comment. As editor of a journal of civil engineering, he had to deal with much construction work of a public character, and his editorials have consistently discussed the broad aspects of such enterprises in which the public is vitally concerned. He has never been one of those who regard the field of engineering as restricted to the materials, the laws, and the forces of nature. On the contrary, he has been a pioneer in advocating the close association of the engineer with matters concerning the public interest and the human relations of society—matters which are now so much discussed in connection with the formation of the Federation of the American Engineering Societies.

In wishing Mr. Baker unqualified success in his new undertaking, we must also tell him that in the years to come we shall greatly miss his frequent and valued contributions to the technical press—we hope they still may be occasional.

Minnesota Proposes State Federation of Architects and Engineers

Representative architects and engineers from all parts of Minnesota recently met at Duluth and took the first step toward the organization of a State Federation of Architects and Engineers. The unanimous sentiment of those in attendance, reports *The American Architect*, was in favor of such a federation. Only by unification into one state-wide organization will the engineers and architects of Minnesota have the power and weight of numbers behind them to force attention to matters of public concern, having to do with problems of engineering and architecture, or with the regulation of affairs affecting their joint interests.

It was pointed out by Max Toltz, chairman of the meeting, that there are about 4800 engineers, architects, and craftsmen in Minnesota. Many of these men are not identified with any existing organization. It is not the purpose of the men who are back of the proposed federation to supplant any existing organization.

National Research Council Elects New Officers

The National Research Council, which was organized in 1916 under the direction of the National Academy of Sciences, has just elected new officers for the year beginning July 1, 1920. These are as follows: Chairman, H. A. Bumstead, professor of physics and director of the Sloane Physical Laboratory, Yale University; First Vice-Chairman, C. D. Walcott, president of the National Academy of Sciences and secretary of the Smithsonian Institution; Second Vice-Chairman, Gano Dunn, president of the J. G. White Corporation, New York; Third Vice-Chairman, R. A. Millikan, professor of physics, University of Chicago; Secretary, Vernon Kellogg, professor of biology, Stanford University; Treasurer, F. L. Ransome, treasurer of the National Academy of Sciences.

The National Research Council was one of the potent factors in development of scientific and research problems during the war. Originally created to deal with such problems, it was re-

organized in 1918 on a peace-time basis and is now functional through five divisions, namely those of Physical Sciences, Engineering, Chemistry and Chemical Technology, Geology and Geography, and Biology and Agriculture.

U. S. Chamber of Commerce Records Its Views on Industrial Relations

Overwhelming approval of a platform setting up twelve principles of industrial relations has been given by the membership of the Chamber of Commerce of the United States in a referendum vote, the result of which were recently announced. The vote taken was on the report of a special committee of the Chamber's board of directors. This report went deeply into the subject of the employment relation and recommended among other things recognition of the right of open-shop operation and the right of employers and employees to deal directly with each other without participation by outside interests.

At the same time the Chamber's membership in another referendum vote has approved a report of its Committee on Public Utilities recommending that strikes by public-utility employees should be explicitly prohibited and that tribunals should be created by law to adjudicate in decisions binding on both parties differences between public utilities corporations and their employees. The vote on the two referenda was the largest ever recorded by the Chamber on any subject.

Sir Robert Hadfield Prize

Sir Robert A. Hadfield, D.Sc., D.Met., F.R.S., has placed in the hands of the Institution of Mechanical Engineers (England) the sum of £200, the income therefrom to be awarded at the discretion of the Council of the Institution as a prize, or as prizes, for the description of a new and accurate method of determining the hardness of metals, especially of metals of a high degree of hardness.

Competitors should familiarize themselves with the ordinary tests of hardness, such as are described in the Report of the Hardness Tests Research Committee (*Proceedings* of the Institution of Mechanical Engineers, 1916, pages 677 to 778). What is desired is the description of a research for or an investigation of some method of accurately determining hardness, suitable for application in metallurgical work in cases in which present methods partially fail.

The Council of the Institution will consider annually all communications received, and may then award a prize or prizes. But in January, 1922, the offer of prizes will be withdrawn, and any unexpended balance of the Prize Fund will be diverted to any other purposes to be determined at the discretion of the Council.

Communications should be accompanied by scale drawings of any new apparatus described, or by a model or an example of the apparatus itself. If the communication describes a new invention likely to be of commercial value, it is desirable that provisional protection should have been obtained before it is submitted for consideration. Communications should be addressed to The Institution of Mechanical Engineers, 11 Great George Street, Westminster, London, S.W. 1.

Monument to Wilbur Wright Is Presented to Le Mans

Tribute to the life and work of Wilbur Wright, American pioneer in aviation, was recently paid by the unveiling in Le Mans, France, of a superb monument. The occasion of the unveiling, on July 17, was a notable one, being attended by a large number of prominent Frenchmen and Americans.

Speeches were made by Baron d'Estournelles de Constant, president of the Wilbur Wright Committee; M. Castille, Mayor of Le Mans; Rear-Admiral T. P. Magruder, representing Hugh C. Wallace, the American Ambassador to France; Comte Henri de La Vauls, M. Stephen Lausanne and Mr. Myron T. Herrick, former United States Ambassador. The dedication exercises concluded with the presentation of the Grand Cordon of the Legion of Honor to Louis D. Beaumont, donor of the monument, a governor of The Aero Club of America, and a prominent patron of aviation during the war.

The Wilbur Wright monument, facing the east in the Place des Jacobins, is the work of the French sculptor Paul Landowski and the architect Bigot. Standing 40 ft. high, its base is carved with figures in bas-relief of Wilbur and Orville Wright and of Léon Bollée. It also carries the names of the precursors of aviation from the time of Dedalus, listing the heroes who gave their lives for the development of the science. It upholds at its summit the splendid figure of a man reaching to the skies.

THE WILBUR WRIGHT MONUMENT

Admiral Magruder, who represented the American Ambassador, spoke in French. He said in part:

> The names of Wilbur and Orville Wright have added themselves to those of the great American inventors, Fulton, Howe, Morse, Edison, and I am proud of the thought that my fellow-citizens have contributed to give the world a finer life than before. Americans are a practical race. What I admire among you, my friends of France, is that you know how to join the ideal with the practical. One will never forget the names of Latham, Blériot, Pégoud, aviators before the great war. During the war, Wright's invention permitted other Frenchmen to make themselves ever famous—Garros, Gilbert, and the incomparable master of the air, Guynemer.

Under the Admiral's supervision a stalwart American marine placed a wreath at the foot of the statue, the gift of the townspeople of Wilbur Wright's home, Dayton, Ohio.

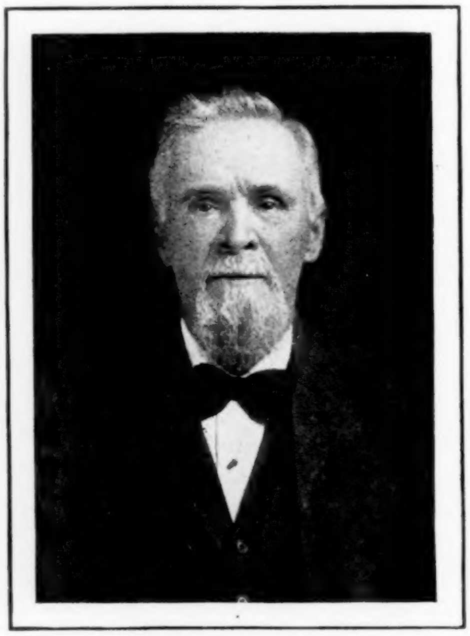
Former Ambassador Herrick recalled the prominence of his home state, Ohio, which has given Edison and the Wrights to civilization, and rehearsed the steps which brought Wilbur Wright to France in 1908. He also lauded the names of American inventors from the time of Fulton and Franklin, revealing their close relation, in their final success, to France and French assistance, and he concluded with a fervent appeal for the fostering of a common Franco-American spirit.

Amos Whitney Dies

Amos Whitney, one of the most conspicuous figures in the early growth of the New England machine-tool industry, a member of the A.S.M.E. since 1913, died on August 5, at the Poland Springs House, Poland Springs, Me. Mr. Whitney was born 88 years ago on October 8, 1832, in Biddeford, Me. He came from distinguished Colonial and English ancestry. In this country the family has continuously held a prominent place, many of its members showing decided mechanical tastes as Eli Whitney, inventor of the cotton gin, Baxter D. Whitney, the Winchendon machine builder, and Amos Whitney.

He was apprenticed at the age of 14 to the Essex Machine Co. of Lawrence, Mass. Six years later he moved to Hartford where he was employed at Colt's Armory, at that time the headquarters for many New England mechanics.

There he met Francis E. Pratt, who left shortly afterward to take charge of the Phoenix Iron Works, and Asa A. Cook. In 1853 Mr. Cook also went to the Phoenix Works as a contractor,



AMOS WHITNEY

taking young Whitney with him as a full partner. While there Mr. Whitney became closely associated with Mr. Pratt, who designed the "Lincoln" milling machines. Whether the idea of the milling machine came originally from Windsor, Vt., as some claim, or originated in Hartford, is difficult to prove at this time; but at any rate the machine is known as the Lincoln milling machine all over the world. In 1860 they determined upon entering business together. They rented a small room where, in addition to their regular employment, they started the manufacture of a little machine for winding thread known as a spooler. Within two years the business had increased to such an extent that they gave up their positions at the Phoenix Works and in 1865 erected their first building on the present site. In 1869 the Pratt & Whitney Co. was formed with a capital of $350,000, later increased to $500,000, and in 1893 reorganized with a capitalization of $3,000,000. In 1893 Mr. Whitney was made vice-president; later he was president, in which office he continued until January 1901, when the control of the company was acquired by the Niles-Bement-Pond Co. Mr. Whitney remained as one of the directors.

Mr. Whitney's unbounded optimism was well displayed when the Pratt & Whitney Co. went through its first panic. It kept right on making standard machine tools, but selling almost nothing, until all the available storage room was filled. Then a large space was hired from the Weed Sewing Machine Co. and when this was filled another large space was hired in Colt's "West Armory" and this in turn was filled with finished machinery. It is well to note as a matter of history that when this immense stock finally did begin to move, it was practically sold out in 30 days.

Mr. Whitney took an important part in the development, in this country, of standard measuring instruments, one of the first moves being a determined effort to secure a standard inch block. His company purchased at considerable expense a standard rectangular bar, 1 in. square and 12 in. long, which had been used as a standard of measurement. Twelve 1-in. cubes were then made as accurately as possible and tested by the 12-in. piece. It was found that the twelve 1-in. cubes were not as long as the single bar, supposed to be exactly 12 in. long. Careful measuring and comparison with such standard instruments as were available led the company to believe that the individual inch-blocks were more nearly accurate than the long piece, and this was afterwards proved by the Rogers-Bond comparator, which was developed in the Pratt & Whitney Works.

At the time of his death Mr. Whitney was president of the Gray Telephone Pay Station Co., and treasurer of the Whitney Manufacturing Co., Hartford, which was organized by his son, Clarence.

Death of Isham Randolph

Isham Randolph, consulting engineer and for fourteen years chief engineer of the Sanitary District of Chicago, died on August 2 in that city. Mr. Randolph was born in Clarke County, Virginia, in 1848. At the age of 20 he started work as an axeman for the Winchester & Strasburg Railroad, thus beginning a long career in which railroads played so large a part.

From 1880 to 1885 he was chief engineer of the Chicago & Western Indiana Railway and the Belt Railway of Chicago, at the end of which period he began private practice in Chicago. The following year he became chief engineer on the construction of the Chicago, Madison & Northern Railway and Freeport & Dodgeville Railway for the Illinois Central Railroad. In 1888 he resumed general practice in Chicago, and was consulting engineer for the Union Stockyard & Transit Co., the Calumet Terminal Railway, and the Baltimore & Ohio Railroad. From 1893 until 1907, when he resigned he was chief engineer of the Sanitary District of Chicago. He was retained, however, as consulting engineer until the end of 1912.

In 1905 Mr. Randolph was appointed by President Roosevelt on the Board of Consulting Engineers for the Panama Canal, and he was one of the five members of the board whose minority report was accepted by the President and Secretary of War, approved by the Panama Commission and adopted by Congress. Again, in 1908, he was one of the six engineers who accompanied President-elect Taft to Panama to consider the advisability of changing the plans for the Canal.

He was chairman of the Internal Improvement Commission of Illinois which made plans for a canal from Lockport to Utica, Ill., of the State Conservation Commission, of the State Rivers and Harbors Commission and of the Chicago Harbor Commission. He made an engineering study, report and plans for a commercial harbor for Milwaukee and was consulting engineer. From 1893 until 1907, when he resigned, he was chief engineer for Toronto and Baltimore on track-elevation work. He served as a member of the Toronto Water Supply Commission. He was also consulting engineer for the Little River Drainage District of Cape Girardeau, Mo., and reviewed the plans and estimates for the Lake Erie and Ohio River Barge Canal. He was chairman of the Florida Everglades Engineering Commission and made a complete report on the drainage of the swamp lands of Florida. The report was accepted by the Governor. He designed the harbor system for Miami, Fla. Upon appointment by the Queen Victoria Niagara Falls Park Commission he designed the Obelisk dam above the Horse Shoe Falls.

Mr. Randolph was past-president of the Western Society of Engineers, and a member of the American Society of Civil Engineers and the American Institute of Consulting Engineers.

The Federated American Engineering Societies

THE Joint Conference Committee, which is acting for The Federated American Engineering Societies in accordance with the instruction of the Organizing Conference held in Washington, D. C., June 3-4, 1920, has sent out to approximately 150 engineering and technical organizations an invitation to become a charter member of the new Federation. An invitation has also been extended to the same societies to appoint delegates to the first meeting of the American Engineering Council which is being planned for this fall and of which more extended notice will be given later.

Copies of the constitution and by-laws of the Federation have also been sent to the above societies. This constitution, which is printed below in full has just been released for publication in accordance with the instruction of the Washington Conference who referred it to an editing committee for revision. MECHANICAL ENGINEERING presents this constitution and by-laws with the hope that its readers will study the form of the new organization which is being set up, for as time goes on changes will doubtless be made, and if the Federation is to prosper it is necessary that these modifications be made in the light of widespread criticism. To this end MECHANICAL ENGINEERING will welcome correspondence dealing with all matters pertaining to the Federation.

Constitution

PREAMBLE

ENGINEERING is the science of controlling the forces and of utilizing the materials of nature for the benefit of man, and the art of organizing and of directing human activities in connection therewith.

As service to others is the expression of the highest motive to which men respond and as duty to contribute to the public welfare demands the best efforts men can put forth, Now, THEREFORE, the engineering and allied technical societies of the United States of America, through the formation of The Federated American Engineering Societies, realize a long-cherished ideal—a comprehensive organization dedicated to the service of the community, state, and nation.

ARTICLE I. NAME

The name of this organization shall be The Federated American Engineering Societies.

ARTICLE II. OBJECT

The object of this organization shall be to further the public welfare wherever technical knowledge and engineering experience are involved, and to consider and act upon matters of common concern to the engineering and allied technical professions.

ARTICLE III. MEMBERSHIP

SECTION 1. *Scope.* The membership may consist of national, local, state and regional engineering and allied technical organizations and affiliations, classified as follows:

1 National engineering and allied technical organizations

2 Local, state, and regional engineering and allied technical organizations other than local associations, sections, branches, or chapters of national organizations

3 Affiliations consisting of any one or a combination of the following constituents:

(*a*) Local sections, branches, chapters, and associations of members of national organizations included under (1)

(*b*) Local engineering and allied technical societies and clubs, not of national scope

(*c*) Local engineers and members of allied technical professions and their associates.

SECTION 2. *Qualifications.* The qualifications for membership shall be as provided in the By-Laws.

SECTION 3. *Application for Membership.* Application for membership shall be made in the form and manner prescribed in the By-Laws.

SECTION 4. *Termination of Membership.* The membership of any constituent organization may be terminated by it or by the American Engineering Council in the manner provided in the By-Laws.

ARTICLE IV. MANAGEMENT

SECTION 1. *Managing Body.* The management of this organization shall be vested in a body to be known as "American Engineering Council," and its Executive Board.

AMERICAN ENGINEERING COUNCIL

SECTION 2. *Functions.* The American Engineering Council shall consist of representatives of Member-Societies selected as hereinafter provided. This council shall coördinate the activities of state councils and of local and regional affiliations whenever these activities are of national or general importance or may affect the general interests of engineers.

SECTION 3. *Representation.* Each national, local, state, and regional organization and affiliation shall be entitled to one representative on the Council for a membership of from one hundred to one thousand inclusive and one additional representative for each additional one thousand members or major fraction thereof; provided, that in the determination of the representation of local, state, and regional organizations and affiliations no count shall be taken of any organization which is represented individually or through another local, state or regional organization or affiliation; and, provided further, that no organization shall have more than twenty representatives on the Council.

SECTION 4. *Selection of Representatives.* Representatives on the Council shall be selected as stipulated in the By-Laws.

SECTION 5. *Meetings.* The Council shall hold an Annual Meeting. Other meetings may be called by the Executive Board and shall be called by it upon the written request of twenty-five representatives on the Council.

SECTION 6. *Officers.* The elected officers of the Council shall consist of a President, to hold office for two years, who shall be ineligible to reëlection, four Vice-Presidents, to hold office for two years, two to be elected each year, and a Treasurer, to hold office for one year. These officers shall be elected by a letter ballot of the representatives on the Council as provided in the By-Laws. There shall be an Executive Officer who shall also be Secretary appointed by and holding office during the pleasure of the Executive Board. He shall not be a member of the Executive Board but may be a representative on the Council.

EXECUTIVE BOARD

SECTION 7. *Functions.* There shall be an Executive Board of the Council constituted as hereinafter provided and charged with conducting the business of the organization under the direction of the Council.

SECTION 8. *Membership.* The Executive Board shall consist of thirty members, of whom six shall be the officers elected by the Council and twenty-four shall be selected, a part by the national societies, and the remainder by the local, state and regional organizations and affiliations according to districts, as provided in the By-Laws: provided, that the number of members representing the national societies on the Executive Board shall bear as nearly as may be the same ratio to the number of members representing the local, state and regional organizations and affiliations thereon, as the number of representatives of the national societies on the Council bears to the number of representatives of the local, state and regional organizations and affiliations thereon.

SECTION 9. *Electoral Districts.* For the purpose of facilitating the selection of the district members on the Executive Board the Council shall, as provided in the By-Laws, divide the United States into districts based upon an equitable representation, having regard to both its membership and area.

SECTION 10. *Officers.* The President and Secretary of the Council shall be, respectively, the Chairman and the Secretary of the Executive Board. There shall be two Vice-Chairmen, elected by the Board from its members.

ARTICLE V. UNEXPIRED TERMS

Vacancies in the offices of the President, the Vice-Presidents, and the Treasurer and in the Executive Board and among the representatives on the American Engineering Council shall be filled as soon as feasible by the agencies originally selecting the incumbents. The officers and representatives thus chosen shall serve for the unexpired terms.

ARTICLE VI. FUNDS

SECTION 1. Funds for the use of the organization shall be contributed as follows:

(*a*) Each national Member-Society shall contribute annually one dollar and fifty cents ($1.50) per member

(*b*) Each local, state and regional organization and affiliation Member-Society shall contribute annually one dollar ($1.00) per member. No portion of such funds shall be applied to the use of local affiliations or state councils.

SECTION 2. The American Engineering Council may receive and administer gifts, bequests or other contributions for carrying out the purposes of the organization.

ARTICLE VII. LOCAL AFFILIATIONS

Section 1. *Object.* The American Engineering Council shall encourage the formation of local affiliations to consider matters of local public welfare with which the engineering and allied technical professions are concerned, as well as other matters of common interest to these professions, in order that there may be united action and that suggestions and advice may be offered to the Council.

Section 2. *Constitution.* Each local affiliation desiring membership in this organization shall submit its constitution and by-laws, and all subsequent amendments thereof, to the Executive Board of the Council for the approval of such portion or portions thereof as may affect its eligibility or its relation to the work of the Council.

ARTICLE VIII. STATE COUNCILS

Section 1. *Object.* State councils, consisting of representatives of local affiliations within the state or otherwise representative of the majority of engineers and members of allied technical professions in the state, if members of this organization, shall consider state matters of public welfare with which the engineering and allied technical professions are concerned, as well as other matters of common interest to these professions, in order that there may be united action in state affairs.

Section 2. *Constitution.* Each state council desiring membership in this organization shall submit its constitution and by-laws, and all subsequent modifications thereof, to the Executive Board of the American Engineering Council for the approval of such portion or portions thereof as may affect its eligibility or its relation to the work of the Council.

ARTICLE IX. DELIMITATION OF AUTHORITY

Local organizations and affiliations, state organizations and councils, if members of this organization, and the American Engineering Council shall deal with local, state, and national matters, respectively, and shall be autonomous with respect thereto. It shall, however, be the duty of the American Engineering Council to interest itself in the activities of local and regional organizations and affiliations and state organizations and councils if such activities are of national scope, or affect the general interest of the engineering and allied technical professions; provided, that nothing herein stated shall be construed as preventing the discussion by any local and regional organization and affiliation or state organization and council or by the American Engineering Council of any matters of interest to engineers and members of allied technical professions, or action by that Council on local or state matters where there is no local or regional organization or affiliation or state organization or council.

ARTICLE X. PUBLICITY

This organization shall stand for the principle of publicity and open meetings, under such provisions as may be provided in the By-Laws.

ARTICLE XI. AMENDMENTS

Section 1. An amendment to this constitution may be proposed by the Executive Board.

Section 2. An amendment may be proposed, in writing, by at least twenty-five representatives on the American Engineering Council. Such amendment shall be considered first by the Executive Board, which shall report on it to the Council, approving or disapproving or modifying it or submitting an alternative amendment. This report shall be accompanied by the original proposed amendment.

Section 3. An amendment proposed as provided in Sections 1 and 2 shall be considered at a meeting of the Council after it has been submitted to its members at least ninety days in advance of the meeting. At such meeting, provided a majority of the representatives be present, the amendment may be rejected, or otherwise submitted to the members of the Council for letter ballot within thirty days thereafter, with such modifications as may be adopted by a majority of those present. The amendment shall require a two-thirds affirmative vote for its adoption.

By-Laws

CHAPTER I. MEMBERSHIP

Section 1. *Qualifications.* Any society or organization of the engineering or allied technical professions whose chief object is the advancement of the knowledge and practice of engineering or the application of allied sciences and which is not organized for commercial purposes is eligible for membership.

Section 2. *Admission.* The Executive Board shall submit to a letter ballot of the American Engineering Council, each application for membership made to it on a prescribed form, accompanied by a statement of its findings as to eligibility and the number of representatives to which the applicant would be entitled. The applicant shall be admitted by a majority vote of the Council, provided, that not more than twenty-five per cent of the members of the Council shall vote in the negative.

Section 3. *Termination of Membership.* 1. Any Member-Society may terminate its membership on June 30 or December 31 of any year after giving at least three months previous written notice to the Secretary of its intention thereof, provided, however, that the financial obligations of such organization are discharged to the said June 30 or December 31, respectively.

2. On complaint brought by any three members of the Council, and transmitted in writing to the Secretary giving reasons why the membership of any Member-Society should be terminated, the Committee on Membership and Representation of the Executive Board shall investigate said complaint, inform itself of all matters pertaining thereto, and report its findings to the Executive Board, which may either dismiss the proceedings or make recommendations to the Council. The Council, by a two-thirds vote of those present at a meeting, may dismiss the proceedings or order a letter-ballot.

3. A two-thirds affirmative vote shall terminate membership.

CHAPTER II. MANAGEMENT

Section 1. *Terms of Representatives.* Representatives on the American Engineering Council shall serve for two years; provided, that after the first election, if there is more than one representative from one organization, approximately one-half the number of the representatives shall be elected each year.

Section 2. *Announcement of Representatives.* Each organization represented shall send to the Secretary of the Council on or before August 15 of each year the names of its representatives who are to serve for the term beginning January 1 of the following year.

Section 3. *Votes of Representatives.* Representatives on the Council and members of the Executive Board shall each have one vote in meetings of these bodies.

Section 4. 1. *Meetings.* At all regular meetings of the Council the order of business shall be as follows:

(*a*) Roll call of representatives
(*b*) Approval of minutes of previous meeting
(*c*) Report of Secretary
(*d*) Report of Treasurer
(*e*) Report of President
(*f*) Report of Executive Board
(*g*) Report of committees
(*h*) Unfinished business
(*i*) Special business
(*j*) New business.

2. *Rules of Order.* Unless otherwise provided, Robert's Rules of Order shall govern the proceedings of all meetings of the Council.

3. *Quorum.* A majority of all the representatives on the Council shall constitute a quorum at any of its meetings.

Section 5. *Nomination and Election of Officers.* 1. The Secretary shall send to each member of the Council at least ninety days in advance of the Annual Meeting, nomination blanks for offices to be filled at that meeting. Nominations received within thirty days shall be canvassed by the tellers appointed by the Executive Board and reported by them to the Board. The Board shall place upon the ballot the names of the three candidates receiving the highest number of votes.

2. The Secretary shall mail to each member of the Council, at least thirty days before the Annual Meeting, the ballot containing the names of the above selected nominees for each office.

3. Ballots received before 7 a. m. of the first day of the Annual Meeting shall be canvassed by tellers appointed by the Executive Board, and the result shall be certified to the President of the Council, who shall announce the result of the election at the Annual Meeting. A plurality of votes shall elect; in case of a tie vote the Annual Meeting shall immediately select by ballot one of the two candidates.

Section 6. *Duties of Officers.* 1. The terms of all officers elected at an Annual Meeting of the Council shall commence on the adjournment of that meeting.

2. The officers shall have the usual duties pertaining to their respective offices except as may otherwise be provided in the Constitution and By-Laws.

3. It shall be the duty of the President to represent the Council on any formal occasion.

4. The Vice-Presidents in the order of their seniority of election and age shall, in the absence or disability of the President, discharge his duties.

5. The Treasurer shall receive all moneys and shall deposit them in the name of the Council with a bank or trust company approved by the Executive Board. He shall invest all funds not needed for current disbursements as ordered by the Executive Board. He shall pay all bills covering expenditures authorized by the budget or the Executive Board, by checks countersigned by the Chairman of the Finance Committee or some other member thereof. He shall make an annual report and such other reports as may be prescribed by the Executive

Board. He shall give a bond at the expense of the Council, in amount and with surety satisfactory to the Executive Board.

6. The Executive Officer shall be appointed and his compensation fixed annually by the Executive Board and he shall hold office during its pleasure. He shall be the Secretary of the Council and of its Executive Board. He shall manage the business of the Council under the direction of the Executive Board and shall perform such duties as may be assigned to him by the Council or the Executive Board. He shall be the custodian of the property of the Council. He shall collect all moneys due the Council and transfer them to the custody of the Treasurer. He shall scrutinize all expenditures and use his best endeavors to secure economy in the administration of the business of the Council. He shall certify to the accuracy of all bills or vouchers on which money is to be paid. He shall give a bond at the expense of the Council in amount and with surety satisfactory to the Board. He shall pay the current expenses of the office, and for this purpose he shall have at his disposal a suitable sum of money to be fixed by the Board, which amount shall be periodically replenished under the authority of the Finance Committee upon the presentation of an account of disbursements in the form required by it. He shall mail to the Member-Societies bills for their annual contribution thirty days prior to the beginning of the fiscal year. He shall perform such other duties as may from time to time be assigned to him by the Council or the Executive Board.

SECTION 7. *Selection of Executive Board.* 1. The Secretary shall submit to the Executive Board, at its September meeting, a list of Member-Societies in good standing with their respective memberships.

2. The Executive Board shall thereupon determine the number of its members for the next ensuing administration year to be selected by national societies, and by the representatives of the local, state, and regional organizations and affiliations, as provided in the Constitution, and it shall prescribe the boundaries of the districts from which the representatives of the local, state, and regional organizations and affiliations are to be selected.

3. The Secretary, within two weeks after the September meeting of the Executive Board, shall mail to the proper officer of each Member-Society a copy of his report on membership and a statement of the Board's action with respect to the membership of the Board, and its delimitation of districts.

4. Members of the Executive Board representing national societies shall be selected by the said societies in such manner as they may determine; the secretary shall be advised of this selection.

5. Members of the Executive Board representing local, state, and regional organizations and affiliations shall be nominated and elected from each of the several districts by the representatives therefrom on the Council, at a meeting duly called for the purpose, provided, three-fourths of all representatives of said district are present or represented; the selection shall be reported to the Secretary.

SECTION 8. *Attendance at Meetings.* If any member of the Executive Board or any of its committees shall fail to attend the meetings of said Board or committee for a period of five consecutive months, not including July and August, he shall cease to be a member of said Executive Board or committee. The vacancy thus created shall be filled as provided for in the Constitution in Article V. on Unexpired Terms.

SECTION 9. *Duties of Executive Board.* 1. The Executive Board shall organize within thirty days after the adjournment of the Annual Meeting of the Council.

2. It shall hold regular monthly meetings except during July and August. Regular meetings shall be held on the second Monday of each month except that a regular monthly meeting shall be held in connection with the meeting of the Council.

3. Special meetings may be called at the discretion of the President and shall be called at the written request of five members of the Executive Board.

4. The Secretary shall mail the notices of each regular meeting at least fifteen days in advance thereof and shall mail notices of each special meeting, stating its purpose, at least ten days or shall telegraph them at least six days in advance, to each member of the Board. No business other than that for which it has been called shall be transacted at a special meeting.

5. A quorum for all meetings of the Executive Board shall be fifteen members.

6. The Executive Board, unless otherwise provided, shall appoint all special committees of the Council and of the Executive Board. The membership of such committees may be drawn from the membership of the Council or of the Member-Societies.

7. The Executive Board shall, whenever practicable, provide for the whole or a part of the expenses of members or of representatives attending its own meetings and those of the Council.

SECTION 10. *Appointment of Committees.* The following committees shall be appointed from the membership of the Board annually by the incoming President with the approval of the Executive Board, each member to serve one year or until his successor is appointed:

(*a*) On Procedure
(*b*) On Constitution and By-Laws
(*c*) On Publicity and Publications
(*d*) On Membership and Representation
(*e*) On Finance
(*f*) On Public Affairs.

SECTION 11. *Duties of Committees.* 1. The Committee on Procedure shall act for the Executive Board in the interim between its meetings, and shall perform such other duties as may be assigned to it.

2. The Committee on Constitution and By-Laws shall report on all proposed amendments, with any modifications thereof it may deem desirable, referred to it by the Executive Board.

3. The Committee on Publicity and Publications shall, when so requested, prepare all public statements and shall have the direction of publications of the Council.

4. The Committee on Membership and Representation shall report to the Executive Board on the eligibility of each applicant for membership and the number of representatives to which it would be entitled. It shall review and report at least ninety days before each regular meeting of the Council the number of representatives to which each Member-Society is entitled. It shall review the existing electoral districts and report thereon to the Executive Board, at least once every two years. It shall report on all questions regarding registration and credentials of the representatives on the Council.

5. The Finance Committee shall have supervision of the finances of the organization. It shall report an annual budget to the Executive Board at least sixty days prior to the end of each fiscal year. The Chairman or some other member of the Committee shall countersign all checks for the payment of money.

6. The Committee on Public Affairs shall report to the Executive Board on all public affairs with which the engineer is concerned or which affect the relation of the engineer to the public.

7. Special committees shall report to the Executive Board.

CHAPTER III. FUNDS

SECTION 1. *Fiscal Year.* 1. The fiscal year shall begin on January 1 of each year.

2. The contributions of each Member-Society shall be payable in advance in semi-annual payments, on January 1 and July 1 of each year, and shall be based upon a certified statement of its membership as of January 1.

3. A Member-Society failing to pay its semi-annual contribution within six months after it is due shall be suspended or dropped from membership at the discretion of the Executive Board.

4. Funds shall be disbursed, as authorized by the budget or the Executive Board, by checks signed by the Treasurer and countersigned by the Chairman of the Finance Committee or some other member thereof.

CHAPTER IV. PUBLICITY

SECTION 1. The privilege of attendance at all meetings of the American Engineering Council, of the Executive Board, and of Committees, when not in executive session, shall be extended to any proper person, but this privilege does not include the right to speak or vote. Any proper person shall have the right to inspect and make true copies of the official records of all meetings of the Council, the Executive Board, and Committees.

SECTION. 2. The Committee on Publicity and Publications may employ a Publicity Secretary whose duty under the direction of the Executive Board, shall be to prepare and supply to the engineering, technical, and general press information concerning The Federated American Engineering Societies, or the engineering world, and to coöperate with the editors of engineering and technical publications in disseminating information in regard to the organization and its activities. This Committee may appoint a coöperating board of engineering editors to counsel and assist in any or all of its activities.

CHAPTER V. AMENDMENTS

SECTION 1. An amendment to these By-Laws may be proposed by a representative on the American Engineering Council or by a member of the Executive Board. The Executive Board shall consider all proposed amendments and mail a copy of such amendments together with its report thereon to each representative on the Council at least sixty days prior to the date of a regular meeting.

SECTION 2. These By-Laws may be amended by an affirmative two-thirds vote of all representatives on the Council present at a regular meeting thereof, provided, that the proposed amendment shall have been mailed to each representative at least thirty days in advance of such meeting.

SECTION 3. Sections 2, 4 (paragraph 1), 5, 6 (paragraphs 3, 4, 5 and 6), 7, and 10, of Chapter II, of these By-Laws, and any By-Law adopted subsequent to ——————— may be amended by a vote of three-fourths of the members of the Executive Board at any regular meeting; provided, that the proposed amendment shall have been presented in writing at a regular meeting of the Board, and transmitted to each member of the Council at least thirty days previous to the date of its adoption.

Engineering and Industrial Standardization

A Review of Standardization Work Now in Progress, Both in This Country and Abroad, as Reported by the American Engineering Standards Committee and Foreign Standardizing Bodies

STANDARDIZATION in all its various phases is now receiving, both in this country and abroad, the closest study, and through the coöperative efforts of engineering societies and associations is rapidly being brought to the point where duplication of effort and the promulgation of conflicting standards will be largely avoided.

The American Engineering Standards Committee which is directing the standardization work in the United States is now engaged with the development of a great variety of standards for engineering and industry. The history of the committee will be found in MECHANICAL ENGINEERING for July 1919 (p. 638), and it is thus sufficient to state at this time that while the original committee was composed only of representatives of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, the American Society for Testing Materials, and the Government departments of War, Navy, and Commerce. Later the constitution was changed so as to permit of the election to membership of other bodies interested and taking part in standardization work. Under this revised constitution five additional bodies have been admitted, thus making a total of 13 organizations now participating in the work of the Committee. These are:

1 Fire-Protection Group, composed of
   National Fire Protection Association
   National Board of Fire Underwriters
   Associated Factory Mutual Fire Insurance Companies.
2 National Electric Light Association
3 National Safety Council
4 Society of Automotive Engineers
5 Electrical Manufacturers' Council, composed of
   Electric Power Club
   Associated Manufacturers of Electrical Supplies
   Electrical Manufacturers' Club.

Standardization Work in the United States

By the creation of the American Engineering Standards Committee the joint action of the above-mentioned organizations along the lines of standardization has been greatly facilitated and the formulation of standards in many fields has been made possible. Under its rules the Committee selects the sponsor or joint sponsors for a given standard, who in turn organize the Sectional Committee which develops the standard. For example, The American Society of Mechanical Engineers and the American Gas Association were selected as sponsors for the standardization of pipe threads. Another society, The American Society for Testing Materials, was made sponsor for standards dealing with tests for portland cement and specifications for fire tests for materials and construction.

This spring the Sectional Committee on Structural Shapes for Ships was organized by the American Steel Manufacturers, The American Society of Mechanical Engineers and the American Society of Naval Architects and Marine Engineers acting as sponsors. The American Bureau of Shipping and the United States Navy are also represented on this Sectional Committee and real progress has been made.

Another subject receiving the attention of the Committee is that of the standardization of shafting. The American Society of Mechanical Engineers has been asked to become sponsor for this work since the Society has already done a considerable amount of work on a set of standard diameters for transmission and machinery shafting. It is proposed that the work when carried on by the Sectional Committee shall be broadened to include the standardization of the method of determining what diameters of transmission shafting should be used for given loads, the dimensions of shafting keys and keyways, and the setting of dimensional tolerances.

Coöperation With Foreign Countries

The American Engineering Standards Committee is also seeking to coöperate with similar organizations in Great Britain, France, Switzerland, Belgium and Holland. The Swiss, for example, have requested coöperation on Standards for Ball Bearings, and the formation of a Sectional Committee is now under way. Sectional Committees for Screw Threads and Cylindrical Limit Gages have also been formed. These Committees will act in coöperation with British Committees dealing with the same subject although so far as screw threads are concerned the American Engineering Standards Committee has a satisfactory understanding with National Screw Thread Commission, an abstract of whose latest report was published in MECHANICAL ENGINEERING for June (p. 337). The British have also asked for coöperation on Standards for Gears, and The American Society of Mechanical Engineers and the American Gear Manufacturers Association have accepted sponsorship for this work.

Another request has come from The Swiss Standards Association, who have addressed a communication to the American Engineering Standards Committee, proposing the international standardization of the widths across flats on nuts and bolt heads. The proposal covers the range of ¼ in. (6mm.) to 3 in. (80mm.) diameter of bolts. The numerical values proposed are a compromise between the United States Standard, the British or Whitworth, and the metric "Systeme Internationale."

Standardization Organizations Abroad

In the accomplishment of such international standardization as is mentioned above foreign standardizing bodies will play an important part, and in order that the American Engineering Standards Committee might intelligently work with these foreign associations, its Secretary, Dr. Paul G. Agnew, during a recent trip to England and the continent secured information regarding the attitude of European countries toward international standardization and the means they possessed for bringing it to pass. In his report of his trip Dr. Agnew described the forms of standardizing organizations existing in Belgium, France, the Netherlands and England. Brief abstracts of these descriptions follow.

Association Belge de Standardisation

This association was organized and began work in 1919. It was organized by the Comité Central Industriel de Belgium with the support of the national engineering societies and industrial associations. The Comité Central, upon which 80 associations are represented, is a strong organization which is playing an important role in the reconstruction of Belgian industry.

There are 37 members of the main committee, 4 representing the Comité Central, 13 representing the national engineering societies, and 20 representing various industrial associations. The latter cover a wide field, among them being the chemical, paper and cotton industries. The government is not represented on the main committee, but is represented on the working committees.

The Belgian association has no arrangement corresponding to sponsorships, the actual standardization being carried out under the general direction of the main committee, and the detailed administration is handled by the central office. Members of the working committees represent the organizations interested in the particular subject in hand, and are named by the organizations. The usual size of these committees is from 10 to 15.

Owing to the industrial position of Belgium, and its commercial relations to other countries, they are planning to make, and in their work so far have made, extensive use of the standardization work of other countries, making such modifications as will adapt it to their needs. Comprised in the work already carried out are a standard series of bolts and rivets. Work now in hand includes reinforced concrete, mechanical power transmission (pulleys, bearings, etc.), water-pipe fittings, specifications for steel bridges, eco-

nomics in coal consumption, and steel sections. The secretary of the Association is M. Gustave Gerard.

Commission Permanent de Standardisation (France)

The French Commission differs from other national standardizing bodies in that it is strictly an official organization, and supported wholly by government funds. It was established by decree of the President of the Republic in June 1918. It is attached to the Ministry of Commerce, Industry, Posts and Telegraphs, Maritime Transport and the Merchant Marine. The Commission itself, which performs much the same functions as our Main Committee, has 24 members, 9 representing various government departments, one representing the Academy of Sciences, and the remainder, national engineering and industrial bodies. Officially, they are appointed by the Minister of Commerce, but they are nominated by the organizations which they represent.

The actual technical work is in charge of 14 committees covering such subjects as: Specifications for metal products; specifications for materials of construction; railways and tramways; machine elements; metallurgy; textiles; heat engines and hydraulic turbines, and materials for the chemical industry.

Special provision was made in the decree establishing the Commission for the coöperation of the government departments in the preparation of specifications, and the subsequent use of the specifications by the departments, but not in such a way as to hamper the departments by restrictions which are too ironclad. The matter is receiving further study in order to enlist the coöperation and support of the many officials in the departments.

The regular procedure is for a committee to submit a tentative specification to the Commission, and the central office submits it to all interested bodies for criticism, (societies, industrial syndicates, government departments, etc.), and the technical press is advised of the matter. The criticisms are digested by the central office, and decisions reached by the committee for final approval of the Commission.

Hoofdommissie voor de Normalisatie in Nederland

The "Main Committee for Standardization in the Netherlands" was organized in 1916, by the Society for the Encouragement of Industry and the Royal Institute of Engineers. Each of these societies names two members of the Main Committee, the total membership of which is 15. The other 11 members are designated by the Committee itself, the term being 3 years. The president, vice-president and treasurer form a small executive committee which meets frequently. There are four regular meetings of the Main Committee a year. As in the case of Belgium, the relatively small size of the country and its industrial and commercial position necessarily affect their s andardization work.

Industrial associations (syndicates) do not seem to be very largely developed in Holland. Often there are not more than three or four concerns in an industry. It would appear that these facts have had an influence on the methods adopted in handling the appointment of working committees, etc. When a member of the Main Committee has the necessary qualifications for the chairmanship of a working committee, he is chosen for it. The other members of the standing committees are chosen by the Main Committee.

The central office does a much larger part of the technical work of standardization than is the case with the other national standardizing bodies. The office opened in July, 1918. There are a total of 16 on the staff. There are two technically trained engineers besides the secretary, one electrical and one mechanical, and it is planned to add a civil engineer and a marine architect in the immediate future. There is a drafting room with an experienced man at the head. A very complete information service is maintained on the various phases of engineering standardization. An elaborate index system covers not only formally published standards, but also technical articles bearing on subjects in which standardization work is going on, or in which it is considered likely that such work will be undertaken. Mr. E. Hymans is the secretary.

The office prepares the material for all committee meetings. In taking up a new subject, for example, all available standards and proposals, both in Holland and in other countries, are shown in comparative tabular or graphic form. But the office goes farther and draws up what may seem to it as a reasonable proposal for the consideration of the committee. Of course, the office has no voice in decisions, and is not to attempt to influence decisions.

The form of publication is unique. Standards are issued as single sheets, perforated for binding in loose-leaf folders. The essential information is given in compact form, any necessary explanatory notes being given on the back of the sheet. The general style is that of a working drawing, and the idea is that they shall be issued directly to the draughtsman in the plant. They are lithographed from drawings, and printed on special paper that does not soil. The price is 15 Dutch cents ($0.06) per sheet. New sheets are being issued at the rate of about one per week.

British Engineering Standards Association

The British Engineering Standards Committee was organized in 1901 by five leading technical societies. It was incorporated in 1918, and the name changed to Association. The general direction of affairs is in the hands of the Main Committee, which constitutes the sole executive authority. There are 24 members, 19 of whom are appointed by the technical societies and the remaining 5 are chosen by the appointed members, two being from the Federation of British Industries.

Sectional committees are responsible for the technical work in different subjects. Working under the sectional committees are subcommittees, which handle smaller subdivisions of the work. Still smaller subdivisions are handled by small committees termed panel committees, or briefly, panels, to avoid the use of the word subcommittee. Most of the detailed work is done in the panels. There are some 275 of these committees, with 1370 members in all. The members of all the different committees constitute the membership of the Association. A general meeting of the Association is held once a year. The government is represented on most of the working committees, but not upon the Main Committee. There are now 40 on the staff of the central office.

The steps in setting up a committee for a new project are as follows: A request must first come either from an association or a government department. A conference is then called at which all interests to be affected by the proposed work are represented. The purpose of the conference, which is presided over by the chairman of the Association, is to determine whether standardization is to be undertaken. In case the decision is that it shall be undertaken, the chairman of the sectional committee is named by the Main Committee. The members of the Sectional Committee are designated by organizations directly interested in the work of the committee. Generally the members so designated add a very few men of recognized standing to complete the committee.

Great stress is laid by the British upon this procedure which has been evolved as the result of 19 years' experience. They feel that wherever there are responsible industrial associations, it is emphatically best to deal with the industry through the association, and to have the members of the sectional committees appointed by the associations, rather than to have them "hand-picked" by a central body. The addition of a few men by the members who are representatives, makes it possible to obtain the services of outstanding men whose services would not otherwise be secured. The financial support of the Association comes from a variety of sources. In the last year contributions were received from 7 government departments, 47 municipalities, 34 railways, 18 industrial associations, and 98 individual firms.

During the war the government requested the Association to take over the formulation of specifications for aircraft material, and this is being continued. Official governmental representation on the International Aircraft Standards Commission is essentially the same as that in the organization created by the Association for standardization in the domestic industry. A similar arrangement exists in the case of the national committee of the International Electrotechnical Commission. A recent development of the Association has been in the field of shipbuilding. There are two sub-committees—one on ships' fittings and one on machinery. An unusual feature of this work is that there is a geographical division between the Tyne and the Clyde, the work being carried on largely independently in the two regions. Perhaps the most important work in this line is the agreement which has been reached upon standard tail shafts.

International Standardization

In concluding his report Dr. Agnew briefly touched upon the question of international standardization. "One heard a great deal of the necessity of international agreement in various lines of engineering result," he writes. "A suggestion has been made by the Swedish organization that there should be a regular publication in which the work of the projects under way in the different organizations could be abstracted. On the continent there has been some discussion of the desirability of a general international organization, modeled somewhat after the national organizations. While some steps have been taken in this direction, there seems to be a general opinion that such an organization would be unwieldy and liable to fall of its own weight. The reason for this view is that in most, if not in all countries, national standardizing organizations are not yet sufficiently developed, and industry itself is not sufficiently well organized, to permit of a general international engineering standards organization. A much less formal approach to the problem, consisting merely of an informal conference of the secretaries of the various national organizations, seems to have received considerable discussion. This last was favorably considered in a meeting of the Main Committee of the British Association, and it is probable that informal inquiries will be addressed to the various national bodies to determine what their attitude might be toward such an undertaking."

NEWS OF THE ENGINEERING SOCIETIES

American Drop Forge Association and American Society for Testing Materials Hold Annual Meetings—Society of Automotive Engineers Meet in Semi-Annual Convention

American Drop Forge Association

TECHNICAL papers on accident prevention, standardization, company stores, pulverized coal and the lubrication of the steam drop hammer, were presented at the annual meeting of the American Drop Forge Association, held at Atlantic City, N. J., June 17, 18 and 19.

Accident prevention with special reference to forge shops was discussed by G. A. Kuechenmeister, Dominion Forge and Stamping Co., Walkerville, Ont., who described scale and treadle guards in use by the Dominion company, explaining how the use of a sweat pad in connection with goggles had been a factor in getting the goggles used, and outlined means for stimulating the interest and enlisting the coöperation of all employees in safety work.

A paper on the standardization of die blocks was read by C. B. Porter, president of the Sizer Forge Co., Buffalo, and chairman of the standardization committee of Forgemen's Exchange. Standardization of sizes of blocks into the fewest number of sections and lengths, he explained, would facilitate prompt deliveries more than any other factor, because it would allow orders from several customers to be combined and made in lots. He suggested that the users make up a list of standard sections with a few standard lengths for each section. The maker could then easily determine the percentage of replacements that usually occur in each grade and size of block and could add the proper number of stock order blocks to each lot order to compensate for any rejections, and any spares that would thus be made in excess of the order could be immediately applied to future loss. The sizes of blocks, steel in blocks, method of forging, annealing and hardening treatment, were also taken up in detail by Mr. Porter.

The operation of the stores department of Cleveland Hardware Co. was described by Edgar E. Adams. Every month a statement is rendered to each foreman showing how much in dollars the supplies used in his department have cost. When this policy was first established it had little effect, but soon the different foremen began to compare amounts they were paying for supplies and a saving began to be noticed. In time the expense of shop supplies was cut down fully 50 per cent.

C. F. Herington, Bonnot Co., Canton, Ohio, quoted comparative cost figures of burning oil fuel and pulverized coal. One company operating ten stills has been spending $18,000 per month for fuel oil. They are about to install a pulverized-coal plant and expect to make with it a saving of $130,000 per year. The cost of the plant completely erected is to be $85,000, so that they will save that cost in about nine months.

Answering an inquiry as to what the minimum daily consumption of fuel oil would be that it would pay to convert to pulverized coal, Mr. Herington said that about 3000 gal. In such case, he added, with present prices of oil, the pulverized-coal plant would pay for itself in less than a year.

The problem of supplying the proper amount of lubricant to the steam drop hammer was discussed by Harry Johnson, Ingalls-Shepard Forging Co., Harvey, Ill. The success attained with any lubricating system in connection with steam cylinders, he remarked, depends on the layout of the steam line and the method employed in draining. In a test conducted on a 12,000-lb. steam drop hammer with the object of obtaining an oil that would lubricate it economically and would leave exhaust steam sufficiently clean for heating purposes, best results were obtained with a product composed of a full filtered cylinder stock compounded with an acidless tallow oil.

An arrangement of a 2-qt. four-feed motor-driven mechanical lubricator used for supplying this oil was described by Mr. Johnson. The oil was discharged into the steam through a siphon atomizer. One drop of oil per minute was supplied for each 2 sq. ft. of wearing surface involved in the circular area of the cylinder and in that portion of the piston rod that passed through the piston-rod packing.

American Society for Testing Materials

The annual meeting of the American Society for Testing Materials was held at Asbury Park, N. J., on June 22-25. The committee on steel, A-1, proposed new tentative specifications for commercial bar steels, covering ordinary commercial carbon bar steels, rounds, squares and hexagons of all sizes, and flats not over 6 in. wide and hot-rolled or cold-finished. The classification is as follows:

GRADES AND CHEMICAL COMPOSITION OF BAR STEELS

Grades	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulphur, per cent
Open-hearth:				
Dead soft	0.05-0.12	0.55 max.	0.05 max.	0.06 max.
Soft	0.08-0.18	0.55 max.	0.05 max.	0.06 max.
15-25 carbon	0.15-0.25	0.66 max.	0.05 max.	0.06 max.
20-30 carbon	0.20-0.30	0.70 max.	0.05 max.	0.06 max.
25-40 carbon	0.25-0.40	0.70 max.	0.05 max.	0.06 max.
35-50 carbon	0.35-0.50	0.70 max.	0.05 max.	0.06 max.
Bessemer:				
Welding	0.12 and under	0.60 max.	0.115 max.	0.08 max.
Soft	0.15 and under	0.70 max.	0.115 max.	....
15-25 carbon	0.15-0.25	0.90 max.	0.115 max.	....
25-40 carbon	0.25-0.40	0.90 max.	0.115 max.	....
35-50 carbon	0.35-0.50	0.90 max.	0.115 max.	....
40-60 carbon	0.40-0.60	1.00 max.	0.115 max.	....
Screw Steel:				
Bessemer screw	0.08-0.16	0.60-0.80	0.09-0.13	0.075-0.15
Open-hearth screw	0.15-0.25	0.60-0.90	0.06 max.	0.075-0.15

At the 1919 meeting, by recommendation of committee A-1, the note which had been added to 43 specifications by action of the Society in 1918, raising the rejection limits for sulphur in all steels and for phosphorus in acid steels 0.01 per cent above the values given in the specifications, was removed from 29 of those specifications, and with respect to the remaining 14 specifications consideration of the removal was deferred until the meeting in 1920. Acting on an agreement that open conditions still obtain, the committee recommended that the removal of the note be again deferred until the meeting of 1921.

The other recommendations of the committee were largely revisions to established and tentative specifications.

Among the technical papers were those dealing with the following subjects: A new method for testing galvanized coatings, offered by Dr. Allerton S. Cushman, president Institute of Industrial Research, Washington; a description of the processes of manufacture, heat treatment and physical properties of large power-forged chain as made at the Boston Navy Yard, presented by Carlton G. Lutts, physical metallurigist of the hull division at the Boston yard; suggestions for more intensive investigations in delimiting the scope and kind of application for the various materials of engineering, contained in President J. A. Clapp's address; a strong brief for molybdenum as an alloying element in structural steel, presented by G. W. Sargent, and a discussion on so-called shattered zones in steel rails by Dr. J. E. Howard, engineer-physicist Interstate Commerce Commission, Washington.

Society of Automotive Engineers

The Society of Automotive Engineers held its semi-annual convention on June 21-25 at Ottawa Beach, Mich.

At the fuel session Dr. W. S. James presented the findings of the Bureau of Standards on intake-manifold experiments. The program of the work, which was undertaken by the Bureau at the request of the committee of the society on utilization of present fuels in present engines, included measurements of engine performance under conditions of both steady running and rapid acceleration with different temperatures of the intake charge secured by three different methods: (*a*) the hot-air stove supplying heated air to the carburetor; (*b*) the uniformly heated intake manifold; and (*c*) the "hot-spot" manifold. Fuel economy was determined for both part and full-throttle operation. The engine which was used was of modern six-cylinder automobile design.

A preliminary series of runs was made with an intake manifold having the tee section of Pyrex glass and motion pictures were taken of the phenomena observed. In but one of the runs the inside walls were completely dry, and this condition was attained only with great difficulty by the direct application of the flames from two blazing torches to the glass tee. The greatest amount of liquid was present in the manifold at 650 r.p.m. and full throttle, the layer being at least 1-16 in. deep in some places. The liquid collected mainly on the lower side of the manifold between the tee and the intake parts.

The main series of runs was made with an exhaust-jacketed intake manifold. Fuel consumption tests were conducted at both full and half load at speeds of 650 and 1200 r.p.m. These conditions were selected as covering the range of average driving from 15 to 25 m.p.h. Acceleration runs were made for which a dynamometer load was selected to correspond with that of a car at about 45 m.p.h. with full throttle. The results thus far obtained were summarized by Mr. James as follows:

1 At constant speed, mixture ratio, and power outputs, the fuel consumption in pounds per brake-horsepower-hour is independent of the temperatures and methods of heating the intake charge within the range tested.

2 The rate at which an engine will accelerate with a given mixture ratio, or carburetor setting, is markedly affected by the amount of heat supplied and its method of application. Within the limits of this work the greater the amount of heat supplied to the charge and the higher its temperature at the intake port the more rapidly the engine will accelerate.

Another speaker at the fuel session was O. H. Ensign, president Ensign Carburetor Co., Los Angeles, Cal., who described a carburetor that has been in use for the last five years on the Pacific Coast, and was designed to handle an intermediate grade of petroleum distillate, known as engine distillate, which has there been supplied to users of motor vehicles. The principle involved for metering the fuel and air is the drop in pressure that occurs at the center of a whirling mass. The suction air whirls in a special chamber at the center of which terminates a pipe connecting with a cylinder provided with small orifices and surrounded by the fuel. The decrease in pressure or suction at the center of the whirl draws fuel through the various passages into the whirl chamber where it thoroughly mixes with rotating air. The device, Mr. Ensign explained, is permanent in its performance and high in fuel economy.

A symposium on engine design was also presented at the fuel session. It consisted of the following papers: Notes on the Use of Heavy Fuel in Automotive Engines, by H. M. Crane; Engine Design for Maximum Power and Economy of Fuel, by C. A. Norman; Saving Fuel with the Carburetor, by W. E. Lay; and Some of the Factors Involved in Fuel Utilization, by P. S. Tice.

That power farming offers a wide field for engineering research was emphasized by the speakers at the farm-power session. O. B. Zimmerman read a paper entitled Analysis of Fundamental Factors Affecting Tractor Design. The paper dealt chiefly with the effect of grade upon speed and drawbar pull and the effect of rolling resistance upon tractor output. Numerous graphs were included to show the variation of some of the factors with others. Referring to the amount of interesting reliable research work that can be done with advantage in the tractor and plow industry, Mr. Zimmerman said:

> When it is realized what the actual expenditure of energy each year on the United States farms really is and that the majority of it can be done by mechanical power; that a very large part of it can be performed by a properly designed tractor and that estimates of this energy expenditure show it in actual horsepower to be greater in quantity than all other energy expenditures of industry in the United States, including mines, manufacturing, lighting, etc., we must admit that every available resource of engineering skill and scientific research must be expended and quickly, to raise the tractor and implement industry to one where the most exact and careful design will be evident from every possible economic standpoint. Basic data must be established along many lines; special test equipment and apparatus must be designed and built; whole series of experiments must be carried out at various seasons and in different soils; these latter must be studied in various conditions of moisture content; plow and engine design features must be shifted and standards adopted toward which the whole industry will then be enabled to work for early sensible economic solutions in the general interest of the nation as a whole.

There were two other professional sessions, on production and on transportation. Some of the papers read at these sessions were: Production Control and Systems of Accounting, by A. C. Drefs; The Workman, an Element in Production, by A. F. Knobloch; Interdepartmental Production Contests, by R. R. Potter; Motor-Bus Transportation, by G. A. Green; and The Relation of the Motor Transport Corps to Commercial Transportation, by Col. B. F. Miller, M. T. C., U. S. A.

ALLOY STEELS IN THE AUTOMOTIVE INDUSTRY

(Continued from page 505)

It will be noted that in this particular test the cast cutter, while run at a slightly lower speed than the standard cutter (93 ft. per min. vs. 109 ft. per min.) took a more severe cut. It cut

TABLE 9 CUTTING TEST OF CAST HIGH-SPEED STEEL MILLING CUTTER

Material	Speed, ft. per min.	Feed, in. per min.	Depth, in.	Length cut, in.	Condition of cutter
Cast iron	60	0.30	0.125	8.2	Good, slight wear
Soft steel	60	0.30	0.219	1.5	Good, slight wear
	71	0.30	0.219	2.5	Slight wear, but cutting smoothly
Rail steel	60	0.30	0.200	1.0	Good
	93	0.30	0.200	0.8	Good
	93	0.69	0.200	4.0	Good
	93	1.31	0.200	2.0	Cutter began to "go," the wear increasing. Millings "blue heat"

A high-speed steel cutter of standard make was tested on the same rail. It had previously been worn slightly, corresponding approximately to the wear resulting from the cast-iron and soft-steel cuts on the cast cutter.

Rail steel	70	0.30	0.200	1.0	Good
	109	0.30	0.200	0.8	Good
	109	0.69	0.200	1.5	Cutter began to "go," one corner burning and wearing down. Millings hot but still "white"

4 in. at 0.69 in. per min. before failure, whereas the standard cutter failed after cutting 1.5 in. at a lower feed of 0.69 in. per min.

Attention is invited to the fact that this test is not presented as being conclusive evidence that cast high-speed steel cutters are either superior or inferior to tools produced from bars or forgings, but is of interest chiefly in showing the refractory nature of the carbides in cast high-speed steel. It indicates that ordinary heat treatment is not sufficient to bring these carbides into solution, and further that good service may be obtained. Probably such tools may be applied to special lines of work.

LIBRARY NOTES AND BOOK REVIEWS

Applied Aerodynamics. By G. P. Thomson. The Norman W. Henley Publishing Co. Cloth, 7 x 10 in., 292 pp., illus., charts, diagrams, plates, $12.50.

This book is the work of a former officer in the Royal Air Force, who, during the War, was in touch with both the demands from the Front and the attempts made to fulfil those demands from home sources. The results presented are drawn from data accumulated during the War, some of which has been or will be published in the Reports of the Advisory Committee for Aeronautics, and the author has also had free access to the staff and records of the Aircraft Manufacturing Company. The work is concerned only indirectly with the mechanical side of aircraft design, but it specializes upon aerodynamics as a branch of engineering, though an account is also given of such progress as has been made on this side of physics from an engineer's point of view.

A number of suggestions for further inquiry and research are made, such as the problems relating to the interaction of aeroplane fuselages, nacelles and the airscrews attached to them. The importance of full-scale work is emphasized, and the problem of stability is dealt with at length. The question of how heavily the wings of an aeroplane should be loaded is discussed and the subject of abnormally large aeroplanes is also taken up. The information given was up-to-date at the time of writing and pains have been taken to point out the cases in which there was any considerable probability of error.

The Coal Catalog, combined with Coal Field Directory for the year 1920. Containing Explanatory Articles on Rank, Usage, Analysis, Geology, Storage and Preparation of Coals. Compiled and published annually by Keystone Consolidated Publishing Company, Pittsburgh. Cloth, 9 x 12 in., 1133 pp., illus., maps, tables, $10.

The second edition of the Coal Catalog, in addition to describing and listing the coal mines of the United States, with the output and operating companies, has added much new data such as the fusion points of ash from the various coals, the specific gravities and weights of coals and the so-called "fuel ratios." A list of national and local associations is included as well as the wholesale dealers in the larger towns and cities. A Directory section follows each state.

Direct-Current Motor and Generator Troubles, Operation and Repair. By Theodore S. Gandy and Elmer C. Schacht. First edition. McGraw-Hill Book Co., Inc., New York, 1920. Cloth, 6 x 8 in., 274 pp., illus., tables, $2.50.

The chief object of this book is to give simple, effective methods for finding and remedying troubles of direct-current motors and generators. In addition, the selection, operation, care and repair of direct-current machinery are analyzed from the operator's point of view. The theory underlying the design of these machines is omitted, as the book is intended for operators, not for designers.

Drainage Engineering. By Daniel William Murphy. First edition. McGraw-Hill Book Co., Inc., New York, 1920. Cloth, 6 x 9 in., 178 pp., illus., plates, tables, $2.50.

This is a general treatise on the drainage of agricultural lands, which indicates the various questions to be considered in connection with a drainage project, and presents the principles involved in the design and construction of drainage works. The author was formerly a drainage engineer in the U. S. Reclamation Service.

Engineering for Land Drainage. A Manual for the Reclamation of Lands Injured by Water. By Charles Gleason Elliott. Third edition, revised. John Wiley & Sons, Inc., New York, 1919. Cloth, 5 x 8 in., 363 pp., illus., maps, tables, $2.50.

This book is prepared to present the essential features of drainage engineering as practiced in this country today and is adapted to the use of professional engineers and students. This edition has been revised and enlarged. The discussion of the hydraulics of flow has been rewritten and new tables for the discharge of tile drains are given. A diagram to facilitate the use of Kütter's formula in the design of ditches and canals has been added, as well as new material.

Die Magnetische Induktion in Geschlossenen Spulen. By Arthur Scherbius. R. Oldenbourg, Münichen & Berlin, 1919. Paper, 7 x 10 in., 91 pp., illus., 7 marks.

This monograph treats of the possibilities, both theoretical and technical, of phase transformation by transformers and machines without commutators. The author discusses these possibilities with special reference to the limits within which technical applications may be possible and gives particular attention to the saturated transformer.

Manual for the Oil and Gas Industry under the Revenue Act of 1918. By Ralph Arnold, J. L. Darnell and others. John Wiley & Sons, Inc., New York, 1920. Cloth, 6 x 9 in., 190 pp., charts, tables, $2.50.

This manual was first issued in 1919 as a bulletin by the Oil and Gas Section of the Bureau of Internal Revenue. The demand having exceeded the supply, this private reprint, in which certain features have been brought up to date, is published.

The book is intended to assist the taxpayer of the oil and gas industry in preparing his Federal tax returns correctly and expeditiously. It is divided into three parts. Part one deals directly with the law and regulations, part two with depreciation, while part three describes methods of estimating underground reserves, especially by means of production curves, a collection of which are included.

A Metallographic Study on Tungsten Steels. By Axel Hultgren. John Wiley & Sons, Inc., New York, 1900. Cloth, 6 x 9 in., 95 pp., illus., 43 plates, tables, $3.00.

As the question of tungsten steels has been studied by several investigators whose views have not always agreed, it is the purpose of this work to bring about a clearer understanding by presenting certain new facts and problems and by critically examining previous results and opinions. The subject is divided into two sections: (1) The transformations of tungsten steel during different heat treatments and the structures thereby formed; (2) Carbides in tungsten steels. Each section contains a review of the results and opinions of previous investigators and the author's own results and conclusions, based on his metallographic investigations at the Institute of Technology of Charlottenburg, the Royal Institute for Testing Materials, Stockholm, and in the Laboratory of the SKF Ball Bearing Co., Gothenburg, Sweden. The paper was written in Swedish in 1918. In its present form it includes a translation of the Swedish paper as well as an appendix containing a critical review of the investigations on tungsten steels of Honda and Murakami.

Popular Oil Geology. By Victor Ziegler. Second edition. John Wiley & Sons, Inc., New York, 1920. Flexible cloth, 5 x 7 in., 171 pp., illus., chart, maps, tables, $3.

The second edition of this work on oil geology has been partially rewritten and new material along the more theoretical lines of geology has been added. The principles important in the examination of prospective oil land have been emphasized and the work of the oil geologist described in some detail. The work is intended to make intelligible to the layman the fundamental principles of oil geology and is written in as clear and simple language as possible.

Practical Chemistry. Fundamental Facts and Applications to Modern Life. By N. Henry Black and James Bryant Conant. Macmillan Co., New York, 1920. Cloth, 5 x 8 in., 474 pp., illus., plates, $2.

It is the purpose of this book to present the fundamental facts of chemistry and to show by the application of those facts to experiences of everyday life that the subject is real and practical. The economic significance of chemistry of growing allied industries has been stressed and the chemistry of growing things has also been considered. Only such topics have been included as young people can grasp and find useful. The book is adapted for class use as a textbook.